PROPERTY OF
PRINCETON UNIVERSITY LIBRARY
RECEIVED NOV 18 1938

THE BULLETIN

OF THE

AMERICAN CERAMIC SOCIETY

Volume 17 NOVEMBER, 1938 Number 11

DR. JULIUS ARON
November 3, 1840, to June 14, 1897

PROF. DR. HERMANN SEGER
December 26, 1839, to October 30, 1893

For story, see page 463

ESTABLISHED 1869

B. F. DRAKENFELD & CO.

INCORPORATED

VITRIFIABLE COLORS

Special and Unique Color Shades Prepared to Meet Individual Requirements

OXIDE COLORS—*For WET and DRY PROCESS Porcelain Enamels*

BODY—SLIP—GLAZE STAINS
UNDERGLAZE—OVERGLAZE COLORS } *For all Types of Pottery—Tile and Heavy Clay Products*

GLASS COLORS—FLUXES—ENAMELS—*For all Types of Glass Decoration*

GOLD . . . SILVER . . . PLATINUM . . . LUSTRE PREPARATIONS

Printing Tissues—Etching Supplies—Oils—Mediums—Banding Wheels—
Brushes—Palette Knives—Perfection Portable Decorating Kilns

**Specialists
In Vitrifiable Colors
Since 1869**

METALLIC OXIDES . . . CHEMICALS

Alumina
Antimony
Arsenic
Barium Carbonate
Bone Ash
Boracic Acid
Borax
Cadmium Carbonate
Cadmium Oxide
Cadmium Sulphide
Cerium Hydrate
Chrome Oxide Green
Clay Vallender
Cobalt Oxide Black
Cobalt Sulphate
Copper Carbonate
Copper Oxides
Drakolene
Drakosett
Epsom Salts
Glass Decolorizers
Iron Chromate
Iron Oxides
Iron Sulphide
Jack Frost
Frosting Compounds
Japanese Ochre Calcined
Lead Chromates
Lepidolite
Manganese Carbonate
Manganese Chloride
Magnesium Carbonate
Manganese Dioxide
Neodymium Oxalate
Nickel Carbonate
Nickel Oxides
Nickel Sulphate
Ochres
Polishing Rouges
Potassium Carbonate
Potassium Chromate
Potassium Bichromate
Powder Blue
Rutile Powdered
Selenium
Sodium Bichromate
Sodium Selenite
Sodium Silico Fluoride
Tin Oxide
Titanium Oxide
Umbers
Uranium Oxide Orange
Uranium Oxide Yellow
Uranium Nitrate
Zinc Oxides
Zirconium Oxide
Whiting

45-7 Park Place, New York

BRANCHES: East Liverpool, Ohio : : Chicago, Illinois : : Works - Washington, Pa.
PACIFIC COAST AGENTS: Braun Corp., Los Angeles : : Braun-Knecht-Heimann Co., San Francisco

THE BULLETIN
OF THE AMERICAN CERAMIC SOCIETY

A Monthly Publication Devoted to Proceedings of the Society and Promotion of Coöperative Research of Technical, Scientific, and Art Questions

VOLUME 17 NOVEMBER, 1938 NUMBER 11

PAPERS

RECENT DEVELOPMENTS IN ZIRCONIUM GLAZES AND THE EFFECT OF VARIOUS MATERIALS ON THE RESULTS*

By C. H. Commons, Jr.

I. Introduction

The data presented here are a continuation of the studies on zirconium glazes which were begun several years ago.[1] The glazes were prepared by milling the weighed ingredients in porcelain ball mills of about 1000-gram capacity. Millings were carried to about 325-mesh particle size, and the slips were applied by spraying on various bodies to as nearly normal thickness or less as practical. The ware was fired in open saggers in a reared position. Temperatures up to and including cone 3 were generally fired in an open, nichrome resistance electric furnace, and the higher temperatures were fired in open-hearth furnaces with city gas as fuel. The rate of firing was quite rapid so as to complete the firing in not more than seven hours. The closed furnace was allowed to cool naturally over night. The last hour of firing was usually such as to bring the ware up to the maturing temperature at the rate of 20°C per hour. Firings were made by pyrometer to a temperature equivalent to the Orton cone desired.

This procedure produced glazes which usually matured at one to two cones lower temperature in a commercial kiln, depending on the cycle of operation.

II. Results Obtained

The compositions of the glazes and frits which were used are given in Tables I to IV.

The results indicate that a good cone 08 clear bright glaze can be made of frit No. 17676–B (Table III) milled with about 6% ball clay. For an opaque glaze, Opax may be added to obtain the necessary amount of opacity. About 10% will produce an opaque glaze for red bodies. The glaze can be hardened by the addition of flint for a clear glaze. For a harder opaque glaze, it is more economical to use Zircopax in place of Opax.

Glaze No. 26331–O (Table I) matures at cone 06 to an excellent smooth bright glaze and does not run badly even at cone 1. This glaze produces excellent results, except that the color is a definite cream-white. The color can be whitened by additions of Zircopax or by replacing all or part of the lead zirconium silicate by zirconium spinel. This glaze should serve as an excellent base for many tints and colors.

Good glazes at cones 05 to 1 may be made of glaze Nos. 26320–K or 26320–N. They are whiter than glaze No. 26331–O but, although they are bright, they lack the high luster and smoothness of glaze No. 26331–O (Table I).

Glaze No. 26326–A (Table II) produces an excellent white bright glaze at cones 3 to 5, and it is especially suitable for building units, etc.

Glaze No. 20448–B (Table II) has found considerable usage as a base for a cone 8 to 12 glaze. The Zircopax content may be varied to obtain the correct amount of opacity for the class of ware needed. By lowering the Zircopax content and increasing both the flint and feldspar content, a glaze is produced suitable for use over white sanitary ware, although for the best color and coverage the Zircopax content is kept relatively high.

III. Effect of Glaze Constituents

In considering the effect of the various constituents on the properties of a glaze, it is realized that these effects necessarily vary with the base glaze. A summary is given of the glaze-batch data.

$CaZrSiO_5$: When ZrO_2 is introduced in the form of this compound, the glaze is generally brighter, of closer-grained texture, whiter, and more opaque.

$ZnZrSiO_5$: If this compound is the only source of ZrO_2, it generally softens the glaze and makes it closer grained. Where favorable, the color, gloss, and opacity are materially improved.

Zirconium Spinel: When used as the only source of ZrO_2, this compound gives varying results, depending on the saturation of the glaze with respect to ZnO and Al_2O_3. If not saturated, an appreciably whiter, brighter, closer-

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 29, 1938. Received March 29, 1938.

[1] C. J. Kinzie and C. H. Commons, Jr., "Effect of Various Zirconium and Titanium Compounds on a Glaze," *Bull. Amer. Ceram. Soc.*, **16** [1] 1–4 (1937).

grained glaze is obtained, which may be more opaque than the same poundage addition of Zircopax. When the glaze is saturated, crystallization is liable to result.

TABLE I
GLAZE BATCH

	26331–O	26320–K	26320–N	26326–A	20448–B
Keystone feldspar	15.92			21.62	35.15
Soda feldspar		24.50	8.17		
Pyrophyllite			16.35		
Flint	7.96	16.35	16.35	25.95	16.23
Whiting				8.67	13.52
Zinc oxide	7.96	4.09	8.17	8.67	1.80
Fluorspar	3.98	1.63	1.63	6.06	
Zircopax				21.62	23.45
$CaZrSiO_5$		8.17	8.17		
Zirconium spinel		12.25	12.25		
$PbZrSiO_5$	15.92				
G–24	39.83				
Ball clay	7.96	8.17	8.17	6.93	9.92
G–14		24.50	24.50		
Borax	0.40	0.41	0.41	0.43	

TABLE II
MELTED COMPOSITIONS OF GLAZES

	26331–O	26320–K	26320–N	26326–A	20448–B
NaKO	3.92	3.74	3.39	2.32	5.63
CaO	1.79	7.04	6.70	8.69	8.23
BaO					
PbO	21.08				
ZnO	8.16	6.72	10.42	7.45	1.96
CaF_2	4.08	1.69	1.61	5.21	
B_2O_3	5.14	5.91	5.62	5.20	
Al_2O_3	7.15	9.98	10.30	6.24	11.71
SiO_2	42.84	55.46	52.98	52.79	55.95
ZrO_2	5.83	9.45	8.94	12.10	16.53

TABLE III
BATCH FOR FRITS

	20511 G–14	15693–B G–17	20407 G–23	17676–B G–24	17662–B G–26
Keystone feldspar				17.46	5.12
Flint	46.15	30.00	19.84	30.29	31.28
Borax	63.55	54.64	39.70		27.32
Litharge			59.17	30.46	
Whiting	36.00			7.86	10.70
Barium carbonate		25.74			10.30
Zinc oxide		20.00			16.00
Soda niter				3.00	
Soda ash		1.86			
Zircopax				3.54	15.38
Fluorspar					4.00
Boric acid				22.34	

TABLE IV
MELTED COMPOSITION OF FRITS

	20511 G–14	15693–B G–17	20407 G–23	17676–B G–24	17662–B G–26
NaKO	10.36	10.00	6.46	3.68	5.21
CaO	20.20			4.41	6.00
BaO		20.00			8.00
PbO			59.17	30.46	
ZnO		20.00			16.00
CaF_2					4.00
B_2O_3	23.25	20.00	14.53	12.60	10.00
Al_2O_3				3.41	1.00
SiO_2	46.15	30.00	19.84	42.82	39.79
ZrO_2				2.30	10.00

$PbZrSiO_5$: This compound causes the glaze to be brighter and smoother, though where crystallization is pronounced, the effect is to promote crystal growth because of the greater fluidity. The opacity produced is not as good as with other compounds, but the product is useful for its effect on the other properties.

$MgZrSiO_5$: A glaze with this compound has a whiter "white" color even than $CaZrSiO_5$, with at least as good opacity, but when used alone in quantities to give sufficient opacity, there is a definite tendency to cause crystallization.

$BaZrSiO_5$: In small amounts, this compound is an efficient opacifier; in larger amounts, it tends to cause devitrification.

Fluorspar: Fluorspar has been generally thought to be undesirable in glazes because of the tendency of fluorine to volatilize easily, causing blisters, and also to have a detrimental effect on some colors. When used in zirconium glazes, these objections do not appear to be valid for the fluorine seems to be held tenaciously.

In a zirconium glaze, fluorspar is highly beneficial. The color is improved, the gloss is brighter, the texture is finer and closer, and the opacity is materially benefited. The maximum amount, which serves best for each glaze, varies between about 2 to 7%, depending on other factors.

Pyrophyllite: When pyrophyllite is used in a glaze, either in place of feldspar or added to the batch, the almost universal effect is to brighten the glaze, to improve the texture, and to whiten and to opacify the glaze slightly. Generally, the addition of a small amount will actually soften the glaze. The amount most desirable depends somewhat on the glaze, but it is generally less than 20% because at that concentration there is a tendency for the material to separate in the slip and float on the top as though it were not wet. This causes greater concentration of pyrophyllite at the surface, which results in scumminess. It is effective, however, in lowering the coefficient of expansion of the glaze.

Zinc Oxide: This oxide is an effective flux for zirconium glazes. The effect is to soften, brighten, and produce a smoother, closer-grained surface with a whiter color. In some instances, it lengthens the firing range of the glaze. Beyond a certain point, the further addition of ZnO causes the glaze to become yellow and to devitrify, sometimes rather sharply. The most advantageous amount seems to be from 5% in some glazes to 10% in others.

Zircopax: The addition of Zircopax to a glaze makes a glaze whiter and more opaque. In several types of glazes, the addition of Zircopax seems to soften the glaze slightly and make it brighter, smoother, and closer grained.

Tremoline: A little tremoline tends to improve the brightness, color, and opacity, but additional amounts cause crystallization.

Syenite: Syenite seems to improve the surface of the glaze, but it spoils the color and reduces the opacity.

TiO_2: TiO_2 improves the surface and opacity of the glaze but causes it to have a yellow color even in small percentage additions.

RESEARCH LABORATORIES
TITANIUM ALLOY MANUFACTURING COMPANY
NIAGARA FALLS, NEW YORK

PROPERTIES OF DINNERWARE BODIES PREPARED BY THE DRY-MIX METHOD *

By R. C. Meeker

I. Introduction

Certain types of ceramic bodies have been dry mixed for quite a long time, but only within the past few years has this method of body preparation received general consideration. There are a number of plants dry mixing bodies for dry-press tile and electrical porcelain but, as far as is known, there are no dinnerware plants using air-floated clays and dry mixing all the body ingredients.

A study of the properties of several dry-mix semiporcelain bodies and a comparison with the properties of a commercial body prepared in the usual manner seemed desirable. It was also thought advisable to note the effect of the use of lignitish ball clays, ground relatively coarse to accentuate any adverse effect these clays might have on the properties of the ware.

Table I

Dry Screen Analyses

	High strength ball clay (%)	Medium strength ball clay (%)	High strength Ga. clay (%)	N. C. feldspar (%)	Pa. flint (%)
+60-mesh	3.2	8.6			
+100-mesh	17.8	17.0			
+150-mesh	12.2	11.8			
+200-mesh	14.6	11.0	0.4	0.5	0.1
−200-mesh	52.2	51.6	99.6	99.5	99.9

Table II

Body Compositions with Their Respective Preparation

	Body and preparation			
	A Dry mixed (de-aired) (%)	B Dry mixed (de-aired) (%)	C Dry mixed (de-aired) (%)	D Commercial (blunged and filter-pressed)
Ball clay (medium strength)	15.0	30.0	11.0	
Ball clay (high strength)	15.0		11.0	(Batch known by author)
Ga. clay (high strength)	15.0	15.0	23.5	
Ga. clay (low strength)	8.0	8.0	8.0	
N. C. feldspar	12.0	12.0	12.5	
Pa. flint	35.0	35.0	34.0	

II. Materials and Dry Screen Analyses

Two ball clays were used in the tests of the dry-mix bodies. One had high green strength and 17% ignition loss. Most of the lignitish matter was intimately associated with the clay and was considered to be an inherent part of the clay; it also had a residue of approximately 1% on a 120-mesh lawn.

The other ball clay had medium strength, an ignition loss of 12%, and a residue on the 120-mesh lawn of 0.13%.

Two Georgia kaolins were used: one of comparatively high strength and the other of low strength. The low-strength Georgia kaolin, which was not immediately available in air-floated form, was used as shipped to plants for the preparation of blunged and filter-pressed bodies. It ranged in size from $^1/_2$ inch down to dust.

The flint and feldspar had no special treatment and were used just as shipped to dinnerware plants.

III. Body Preparations and Methods

The body ingredients were mixed dry for four minutes in a machine with a capacity of 100 lb. Sufficient water to develop plasticity was added, and the machine was run an additional 6 minutes to give a total mixing and tempering time of 10 minutes. At the end of the initial mixing period, much of the low-strength Georgia clay could be distinguished in the dust, but this material, from visual inspection, was apparently evenly distributed throughout the body shortly after water was added.

Body C was the first body prepared, and several hundred pounds of it were run through the plant pug mill which had no de-airing attachment. The body was not workable, but a second pugging improved the working properties to the point where the clay could be jiggered. No tests were made on this body in the green and fired state, but the large number of 7-in. plates, jiggered and fired, provided a comparison in appearance with the dry-mix body ware, prepared for the most part under factory conditions, and a blunged, lawned, and filter-pressed body in production.

Table III

	Body			
	A	B	C	D
Mercury (in.) (pug mill)	27	$27^3/_4$	$27^3/_4$	Plant body (not de-aired)
Water content (%)	23.5	22.3	22.7	22.8
Linear dry shrinkage (%)	6.0	5.6	5.1	5.5
Total shrinkage (cones 9–10)	10.5	9.6	10.5	10.7
Absorption (7-in. plates) (%)	12.1	12.5	4.6	9.1
Dry modulus of rupture (lb./sq. in.)	629	678	657	660
Fired modulus of rupture (lb./sq. in.)	4290	4620	4870	4690
Impact value	4.7	4.9	4.1	4.7
Heat shock 212 °C to water 12 °C (five quenchings)	No crazing; no dunting	No crazing; no dunting	No crazing; few edge dunts	No crazing; few edge dunts
Autoclave test (100 lb. for 3 hr.)	5 plates O.K.; 3 dunted	7 plates O.K.; 1 dunted	O.K.	O.K.

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 30, 1938 (Materials and Equipment Division Special Session on "Dry Mixing"). Received March 30, 1938.

Later trials were made, using a laboratory de-airing pug mill, and the physical properties of all dry-mix bodies studied were on de-aired clay.

Seven-inch plates were jiggered in two dinnerware plants and were fired in gas-fired tunnel kilns between cones 9 and 10. Commercial glazes were applied to the biscuit ware, and the pieces were fired to cone 4.

IV. Tests

Impact values were calculated by measuring the drop in inches of 1-ounce steel ball, divided by the thickness in millimeters. A value of 4 was considered to be satisfactory.

V. Discussion

The physical properties of the experimental bodies, prepared with a dry mixer and a de-airing pug mill, compare favorably in every way to those of the commercial body D test. The working properties of the bodies were reported good by the jiggermen, and the ware finished nicely. The plates dried and fired equally as straight as the same shapes made from filter-pressed clay.

The heat-shock and autoclave test results on bodies A and B were exceptionally good. The dunts developed in the autoclave tests were rather unusual and were thought to be caused by strains in the ware.

Bodies A, B, and C were jiggered, finished, and placed in the kilns on the day following to obtain fired trials and test data as quickly as possible. Each of these bodies showed some specking, which was no doubt caused by the fact that they were not dry when they were placed in the biscuit kilns, and oxidation was incomplete before the vitrification period. Body C, prepared in the dry mixer and pugged twice, compared favorably in cleanliness and general appearance with commercial body D and with the ware from several plants where check tests were made.

VI. Summary

The use of air-floated clays in conjunction with a dry-mix machine and a de-airing pug mill seems to offer possibilities in the plastic process manufacture of dinnerware as well as in the plants making dry-press ware. The results also indicate that ball clays with carbonaceous matter intimately associated with them can be advantageously used as long as the residues ordinarily caught on the lawn and the clays fire relatively clean.

Acknowledgment

Several parts of this investigation were made possible by the Steubenville Pottery Co., Limoges China Co., Royal China, Inc., and Edwin M. Knowles China Co., and their assistance is gratefully acknowledged, as is the assistance of the Lancaster Iron Works and the Bonnot Company in the body preparations.

Laboratory
Kentucky-Tennessee Clay Company
Alliance, Ohio

SYMPOSIUM ON GLAZES

Editor's Note: The "Symposium on Glazes" was presented in a General Session at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 31, 1938.

Part of this series has been published. See A. M. Blakely, "Life History of a Glaze: I, Maturing of a Whiteware Glaze; II, Measurement of Stress in a Cooling Glaze," *Jour. Amer. Ceram. Soc.*, **21** [7] 239–51 (1938).

PROBLEMS IN WHITEWARE GLAZES*

By Edward Schramm

I. Introduction

Glazes may be described as "glasses applied as covering to clayware." On the basis of composition and properties, it is difficult to define the one in terms which will exclude the other. Nevertheless, the differences in conditions of production and use give rise to a host of problems peculiar to glazes, especially to whiteware glazes. Generally speaking, such glazes may be regarded as high-alumina, high-viscosity glasses. While it is true that glazes have been made without alumina and that most glasses now contain alumina, the presence of a considerable quantity of that element, usually in a molecular ratio of $^1/_8$ to $^1/_{10}$ the silica content, is the distinguishing characteristic of glazes from the viewpoint of composition. The alumina serves (1) to prevent devitrification, (2) to promote fusion if used in the proper amount, (3) to increase the viscosity of the molten glaze, and (4) to give a composition more nearly related to the body than is that of an ordinary glass.

It would be out of place at this time to attempt an exhaustive discussion of glaze compositions, for these are myriad and merge gradually one into the other. Certain broad outlines, however, may be sketched to furnish a background for this discussion. At one end of the scale, there are the simple, easily fusible lead silicates; at the other, the refractory true porcelain glazes. If, with the usual materials at hand, a glaze were devised of intermediate character to suit a particular body and set of firing conditions, three methods would be available, *viz.*, (1) to study all possible combinations of the base materials (a scientific but laborious procedure); (2) to proceed from the simple to the complex, starting with the most fusible lead silicate and, by suitable additions, to develop it into a useful glaze (in this process silica, lime, alumina, alkalis, and boric acid would be added); and (3) to proceed from

---

* Paper No. 2 of the Glaze Symposium discussions. Received March 31, 1938.

the known to the unknown, starting with Seger's work on pyrometric cones, probably the most fruitful ceramic research ever carried out.

Seger determined the most fusible composition obtainable with mixtures of whiting, feldspar, kaolin, and flint, which became cone 4 in his series, with RO formula, 0.7 CaO, 0.3 K_2O, 0.5 Al_2O_3, and 4.0 SiO_2. This composition fuses to a glaze at cone 10, the softest typical porcelain glaze obtainable. In the production of two-fire whiteware, cone 7 generally can not be exceeded. Glazes for this temperature are easily derived from the cone 4 mix by the addition of 15% or more lead borate. Such addition must be made in the form of a frit, so that the studies have now passed into the field of fritted glazes. Other elements, such as Na, Mg, Zn, and Ba, may be added, and the true porcelain glazes are also modified by the use of a number of basic fluxes.

II. Glaze Requirements

A study of the literature on glazes reveals much preoccupation with the question of crazing, and the criterion of a good glaze is the possession of thermal expansion and elastic properties which assure a good fit to the body. In recent years, it has been found that the cause of crazing may be more than "skin deep" and that delayed crazing is primarily due to after-expansion of the body caused by moisture absorption. Mellor has given an excellent review of this subject.[1] In the present discussion, all this is taken for granted. The other requirements of an ideal glaze are as follows: (1) the glaze must be smooth, uniform, lustrous, and free from imperfections, *i.e.*, it must have a brilliant appearance; (2) wherever underglaze or inglaze colors are used, the glaze composition must be such as to bring out their best development; and (3) the finished glaze must have the maximum of serviceability, *i.e.*, the greatest resistance to mechanical wear and chemical disintegration. These conditions are not met easily or naturally by any one type of glaze. Thus the high lead glazes are characterized by a brilliant appearance, owing to their fluidity, and to the high index of refraction of lead glasses; their very fluidity, however, renders them unsuitable for underglaze colors, and their low silica content gives them a low resistance to abrasion. The true porcelain glazes, on the other hand, while inherently hard, are usually lacking in smoothness and brilliance; a rough, imperfect surface, furnishing points of attack for mechanical and chemical forces, may thus counteract the advantage of a hard composition. Such glazes, moreover, because of the necessarily high firing temperature, destroy the more delicate underglaze colors.

III. Glaze Application

Any particular glaze may give good or poor results, depending on the conditions of application and firing. The first problem, therefore, is to study the manner of applying glazes with a view to securing the greatest uniformity. Two methods are available, *viz.*, dipping and spraying. The latter is of increasing importance, but dipping is still more widely used in tableware production.

(1) Greenware Dipping

The conditions for dipping, and indeed the very nature of the process, depend on the type of ware. At one extreme, there is the problem of dipping greenware for single-fire porcelain, passing from that to extremely porous prefired porcelain through earthenware of varying porosity, finally reaching the nonporous biscuit characteristic of American vitreous china.

In the most porous products, formation of the glaze layer depends entirely on capillary attraction of the body. If the slip is too heavy, an excessive deposit is built up; by thinning the glaze, a condition is reached wherein the layer has the required thickness. This occurs when the specific gravity of the slip is about 1.40 and the fluidity is high. With this variety of dipping, there is no after-release of air bubbles through the glaze layer causing pinholes, because the water is absorbed uniformly over the surface and the glaze dries almost immediately after the ware is removed from the tub. This process assures a high degree of uniformity, and it is therefore best adapted to the application of colored glazes in which any unevenness is noticeable. Its utility, however, is decidedly limited. In the usual case of dipping greenware, only the heavy shapes will stand immersion. In casting shapes prior to dipping, salts are added which tend to accumulate at any sharp edges and cause blistering in the fire. Lastly, the decorating possibilities are greatly restricted by this method of glazing.

(2) Vitreous Biscuit Dipping

At the opposite extreme to greenware dipping is vitreous biscuit dipping, which depends entirely on the surface adhesion of thick slips because the body has no capacity for water absorption. It is more difficult to secure uniform covering, and the consistency of the slip must be carefully regulated. This technique, however, is not without its advantages, *viz.*, (1) the glaze dries slowly, making it possible to touch up the places where the ware has been handled; (2) underglaze decorations done in oil colors can be covered; and (3) there is no tendency for release of air through the glaze layer because of the total lack of absorption.

(3) Intermediate Porosity Body Dipping

Between these extremes, there are cases of bodies of intermediate porosity in which dipping involves both absorption and adhesion; *e.g.*, the bulk of the white earthenware produced lies in this intermediate class. Naturally, the specific gravity of slip suited to this condition must likewise be intermediate. Under some conditions, pinholing of the glaze is observed with intermediate porosity bodies. This is a consequence of the dual effect. If the glaze layer is formed chiefly by adhesion, absorption of water by the body will continue after the dipping operation. Such absorption forces the release of air under the still wet glaze layer, producing unsightly pinholes and blisters.

(4) Spraying Effects

The condition of the body affects spraying as well as dipping, and in the same general sense. The more porous the ware, the thinner the slip required. Spraying offers the possibility of a uniform general distribution of glaze regardless of the nature of the biscuit. As against

[1] J. W. Mellor, "Crazing and Peeling of Glazes," *Trans. Ceram. Soc.* [Eng.], **34** [1] 1–112(1935); *Ceram. Abs.*, **14** [9] 233 (1935).

this, it involves danger of localized inequalities, giving the well-known "orange-peel" texture common in enamels. This effect is due to the rippling of the slip deposit by the impinging air stream; it is exaggerated if an attempt is made to build up the glaze layer too rapidly through a combination of thin slip and heavy pressure. If the work is placed too near the nozzle, this defect is sure to occur. On the other hand, an air pressure too low for the weight of the slip may give trouble, owing to incomplete atomization. The best conditions for vitreous ware are through the use of a finely atomized, diffuse spray produced from the heaviest possible slip with the least possible pressure.

IV. Glaze Consistency Control

The control of consistency is no less important with glazes than with casting slip. Glazes are highly individual in this respect, their behavior varying with composition, manner of preparation (especially grinding), the character of the water supply, and the nature of the reagent used for setting up. Certain broad relations have been pointed out by Schramm and Sherwood.[2] Thus, raw porcelain glazes reach dipping consistency at a much lower specific gravity than the fritted type, which reduces the extent of variability in properties. With fritted glazes, the "body," as measured by viscosity in general, increases with the degree of fineness. Instances of the opposite effect, however, have been observed. Thus, if a frit is ground first alone and the raw part of the charge is added toward the end of the operation, a finer state of subdivision is obtained, but the glaze may be more fluid than if the whole is ground together. This happens when the frit is of such character that considerable solution of alkali occurs, causing complete deflocculation. Apparently the clay and other raw ingredients added later do not absorb this alkali to counteract the effect, although when added in the beginning they appear to do so. Whether or not the explanation offered is adequate, the anomaly of an increase in fluidity with finer grinding has been repeatedly observed.

Glazes for dipping must be neither completely dispersed nor completely flocculent but rather in an intermediate state. If the fluidity is too great, the glaze runs off the ware; if it is insufficient, the application will be too heavy and it will be impossible to secure uniformity. Even with the same glaze, the point of control must shift according to the nature of the piece to be dipped. Thus, with flatware considerable fluidity is required to obtain even distribution, whereas with cups and other hollowware requiring a thinner glaze layer it is necessary to work at a lower specific gravity and prevent running off by the use of additional flocculating agents. Such agents are by no means identical in their effects. It can not be said that the property of consistency is entirely understood, but its analysis into the two factors of "yield value" and "mobility" is serviceable in interpreting many of the phenomena. The usual control by the determination of "viscosity" gives a result dependent on both factors; it is nevertheless valid when applied within a narrow range of conditions.

To compare the effect of different agents on slips, however, the complete analysis is essential. Thus, with a certain glaze it was found that an acidlike acetic or an acid saltlike aluminum sulfate caused "setting up," chiefly through lowering the mobility with little or no effect on yield value; borax and especially calcium hydrate increased both yield value and mobility. With a reagent of the former type, the glaze does not flow readily because of low mobility, but neither does it adhere tenaciously to the ware, owing to its low yield value. Glazes of low yield value can be applied only at higher specific gravity. The effect produced by borax or lime is more favorable because the high mobility promotes the necessary flow of the excess glaze, whereas the high yield value gives a tenaciously adherent thin layer. These reagents must be ground in with the charge to obtain their full effect. If used in an excessive amount, the glaze may set up to a paste entirely unfit for use. Something of this nature has been observed with the first charge from a newly lined mill, the glaze taking up lime from the cement used in setting the blocks. The addition of a little water glass is effective in counteracting such excessive gelation.

V. Firing of Glazes

Unless the problem of application has been solved, it is useless to hope for good results in firing; even with the best possible application, many new difficulties arise in the firing process. (To deal fully with these would open up the whole subject of ceramics, so these notes will have to be confined to a brief discussion of the more important factors.)

It is a commonplace, when dealing with ceramic bodies to point out the importance of physical variables on these incomplete reactions in heterogeneous systems. In dealing with glazes, it is sometimes tacitly assumed that only composition need be considered because the glaze is regarded as a glass of definite fusion characteristics fixed by composition and firing temperature. The analogy with glass may be misleading because (1) glasses are brought to a very fluid condition by heating to temperatures much higher with respect to their composition (glazes do not usually progress beyond a viscous condition); and (2) owing to its thinness, the glaze is sensitive to external conditions and is affected by the extent and nature of its interaction with the body. The situation in firing glazes is therefore much the same as with bodies, *i.e.*, all the factors must be closely controlled, a control which begins with the preparation of the slip.

Finer grinding promotes good development, but there is a limit fixed by dipping and drying requirements. The proportion of frit and the distribution of various ingredients between frit and raw charge are important. Thus, with some glazes, the elimination of whiting from the raw charge improves smoothness because the CO_2 does not have to be disposed of in the final firing. With a more refractory type of glaze, which remains open at the temperature of decomposition of calcium carbonate, such a shift may have no effect whatever. Cases have been observed where an interchange of feldspar and flint between frit and raw charge had a profound effect on glaze development; by increasing flint and decreasing feldspar in the raw charge, the glaze became distinctly more refractory. As another example, glazes have been en-

[2] E. Schramm and R. F. Sherwood, "Some Properties of Glaze Slips," *Jour. Amer. Ceram. Soc.*, **12** [4] 270–73 (1929).

countered in which development was improved by a low temperature calcination of the clay portion, caused either by the elimination of the water and its possible disturbing effect or by increased activity of the dehydrated clay.

The course of glaze development during firing is an interesting subject which has had little attention. A recent paper by Rieke and Tanne[3] treats this subject with respect to high-fire porcelain glazes. With such glazes, the sintering occurs in a comparatively narrow temperature interval, but with the fritted type the fusion process must be less sharp, owing to the presence of fluxes active at low temperatures.

Some years ago, the writer made a series of draw trials of a cone 6 glaze applied to small butters and fired in a gas muffle furnace. The ware was decorated with an underglaze green line, which afforded a visual index of the condition of the glaze. The observations were as follows:

Temp. (°C)	Condition of glaze
500	Texture-like raw glaze
700	Partly sintered; could be rubbed off
800	Could not rub off; no glassy appearance
900	Granular appearance; lines show through plainly
1000	Mat glass; lines clear
1100	Fairly well-developed glass
1150	Normal finishing point; glaze "sucked"
1180	Glaze badly "sucked"

The final appearance was marred by the "sucking" effect, an excessive volatilization of fluxes caused by the movement of gases over the ware, but the point of interest here is the wide temperature range of the sintering process. This means that the development of the glaze is influenced by the course of the firing below its maturing point.

In another experiment, it was shown that a slower approach gave a more perfect glaze and that a long hold at the maturing temperature improved smoothness. Quite apart from the effect of time and temperature on glaze reactions, the purely thermal requirement of uniform heat distribution demands a certain amount of soak. This is not as critical a factor as in firing bodies, but poor glaze development caused by uneven heating is common, especially with larger pieces.

(1) Effect of Gases

Lead glazes are sensitive to gas conditions; with extreme reduction (by hydrocarbon gases) such glazes may come out entirely black. Below this extreme, there are a number of effects scarcely less damaging. For instance, the direct contact of flame, even though highly oxidizing, yields a characteristic "struck" effect, the glaze becoming rough, dull, and devitrified, owing to an impoverishment in fluxes. Close proximity of a glazed piece to a refractory surface gives a somewhat similar phenomenon; in this case, owing to absorption of lead and other volatile ingredients by the refractory which promotes further volatilization from the glaze, there is in effect a continuous distillation process. To inhibit these phenomena, it is necessary to protect the ware perfectly from kiln gases by means of saggers and wads and to apply a lead wash to the saggers to build up the necessary vapor pressure without abstraction of too much lead from the glaze.

[3] R. Rieke and C. Tanne, "Sintering and Melting Process in Porcelain Glazes," *Ber. deut. keram. Ges.*, **16** [4] 147–58 (1935); *Ceram. Abs.*, **14** [10] 252 (1935).

(2) Effect of Sulfur

The damaging effects of sulfur are generally recognized, and the remedies are obvious, *viz.*, the use of low sulfur fuels and the maintenance of oxidizing conditions through adequate excess of air. One form of sulfuring, the appearance of a superficial crystalline patch in the center of the piece, is especially troublesome and has been found to occur where there are "pockets" in the kiln, *i.e.*, areas where the gas circulation is inadequate. This sulfur scum develops at the upper temperatures and is a sign of too tight firing.

(3) Effect of Water Vapor in Kiln Gases

Water vapor in the kiln gases usually plays a part in "gassing" effects, because gases, which are perfectly harmless when dry, may be damaging in the presence of steam. All commercial fuels contain hydrogen so that there is no possibility of dealing with this problem by elimination. When firing with coal, however, the burden may be unnecessarily great, if the fuel is not thoroughly dried. Excess moisture, in addition to overloading the kiln gases with water vapor and constituting a burden on thermal efficiency, has a bad effect on the combustion process; it leads to caking, impaired draft, and incomplete combustion, thereby increasing the danger of "gassing" in the glost kiln.

VI. Nature of Glaze Body Reactions

One of the prime factors in glaze development is the nature of the body, its firing characteristics when using the true porcelain process, and in all cases the extent and character of its reactions with the glaze. The interaction of body and glaze may take one of two forms. The body may feed on the glaze either through direct physical absorption or chemical action, or the glaze may attack the body with a resultant increase in its viscosity and refractoriness. These dual effects are not always sharply distinguishable and may both be involved in any given case. Thus, with a high-fire porcelain, the glaze may be applied either to the greenware or to the ware prefired below its maturing temperature; in the latter case, a more perfect, lustrous glaze is obtained because the prefired body reacts less actively with the glaze than the green body. Bodies of a highly absorptive nature, *e.g.*, those containing much free aluminum oxide, may take up most of the glaze in the course of the firing when the latter fuses at a temperature at which the body is still highly porous. To obtain a good glaze with bodies of this type, the composition must be so refractory that the glaze fusion is delayed until the body approaches vitrification. High talc bodies are an extreme example of the tendency to absorb glaze by chemical action; the ordinary porcelain glazes disappear entirely when fired on such bodies by the one-fire process.

When glazing biscuit ware by the two-fire process, the problems of glaze and body reaction are less acute but are by no means negligible. It has been observed that with the same glaze fired on different bodies, but with other conditions identical, marked variations in smoothness and luster occurred. To obtain an indication of the origin of this phenomenon, a simple experiment was carried out. Thin washes of the following materials were applied to greenware: flint, calcined clay, raw clay, feldspar, and alumina. The samples were biscuited, glazed, and glost-

fired together with normal untreated ware. The surface layer under the glaze had a most striking effect on the development of the glaze. The most perfect result was obtained over the alumina wash; the silica wash yielded a glaze which was immature, rough, and without luster. The other materials ranged between silica and alumina in their reaction, giving results more closely approaching normal. It appears, therefore, that the hardening of the glaze composition through solution of silica from the body may be a frequent cause of unsatisfactory glaze development.

VII. Analytical Study of Glazes

Hall[4] has carried out an analytical study of the composition changes involved in firing a typical cone 6 fritted glaze on a vitreous china body. The chief elements in the problem are the interaction at glaze-body interface and the loss by volatilization from the glaze surface. A complete solution would be extremely laborious because it would require analyses of the vapor phase, of the glaze itself, and of the outer portion of the body. An approximate solution can be arrived at more simply by analyzing only the fired glaze and determining the weight changes on firing. To obtain samples for the glaze analysis, a plate was covered with a strong fish-glue which, upon drying, broke fragments out of the glaze layer. The loss in weight on firing was determined for a glaze applied to a square of platinum gauze (eliminating the effect of the body reaction) and for a glaze applied to ware in the normal fashion. In each case, the theoretical ignition loss of the glaze is subtracted as a blank from the observed loss to give the net loss (or gain) by volatilization (or condensation).

The data so obtained yielded some interesting information. The loss by volatilization was always considerably greater from the top plate of a bung or whenever a large free space existed over a glaze surface. This loss increased with glost temperature and with thickness of the glaze layer. With a thin glaze and a moderate glost temperature, an actual gain in weight or condensation was observed. With normal dipping, the loss by volatilization ranged from 0.5 to 2.5% of the glaze weight, depending on position and fire; this loss was not enough to account for the changes in composition given by the analyses.

The analyses of the glaze, when compared to theoretical values, showed an increase in silica and alumina; the relative gain in alumina was considerably greater than in silica. The potash content was practically unchanged, whereas all the other elements showed losses. The lime content dropped off by 1% or more; inasmuch as lime is nonvolatile and no lime had ever been detected in condensate from the kiln gases, it is apparent that the glaze was being robbed of that element by the body. This conclusion was confirmed by analyzing the glaze fired on a platinum gauze. Instead of reduction in lime, a normal slight increase was observed. The constancy of the potash content is consistent with the fact that potash in body and glaze is approximately equal so that there is no tendency for diffusion in either direction. In the case of lead oxide, the observed loss is probably divided between volatilization and absorption by the body. As a result of both effects, the glaze loses more material than it gains.

Analysis of the dust condensed in the exit end of a saggerless glost muffle kiln showed it to consist of 90% lead and boric oxides. The stalactite formed at the end of the hot zone also showed a high PbO and B_2O_3 content with smaller amounts of alkalis and other fluxes from the glaze.

The course of the glaze reactions was also studied in an entirely different manner. Draw trials were made of glazed pieces over a range of temperature to cover the course of fusion. Thin sections revealed that the initial fusion occurs at the glaze-body contact with progressive development to the outer surface of the glaze. The fining of the glaze occurs in the same manner. The earliest reaction appears to be a combination of frit and raw lime. The quartz is the last constituent to be completely dissolved, and in the case of a low glost fire, quartz grains will remain undissolved in the final glaze.

In conclusion, it need only be observed that the glaze problem is one of great complexity. No simple prescription for success can be given, and a study and control of working conditions is essential to supplement the results achieved through a study of glaze composition.

Onondaga Pottery Company
Syracuse, New York

[4] F. P. Hall, private communication.

THE APPLICATION OF GLAZES*

By Lawrence H. Brown

I. Influence of Varying Amounts of Plastic on the Drying Time of a Semivitreous Glaze

A crude experiment was run on a semiporcelain glaze to determine whether any straight-line agreement existed between the drying time of the glaze on the ware (approximately 7% absorption) and the content of plastics. The composition of the glaze was as follows:

	(%)
Frit (according to Mayer formula)	49.01
Canadian feldspar	2.83
Whiting	0.83
Harshaw lead bisilicate	24.28
International No. 109 zinc oxide	3.13
Tin oxide	2.64
Flint	11.52
Uranium ivory stain	2.00
Fla. clay	5.73
	101.97

The same glaze was made up with an equivalent amount of calcined clay substituted for the raw Florida clay. Blends were made between the two end members (29½ oz. per pt.), which had been given comparable grinding preparation except insofar as their dissimilarity in clay content would produce some difference in grain-size percentage.

Weighed bisque semivitreous samples were hand-dipped in the various blends, the exact time taken to dry sufficiently for handling was observed in seconds, and the weight of the glaze plus any water absorbed was recorded. Glaze No. 1 contained no raw clay, and glaze No. 11 contained no calcined clay.

Because the variation in viscosity would produce some difference in drying time, owing to a variation in the amount of glaze adhering to the bisque samples, the weights of the various coatings are given in Table I.

Table I

No.	Drying time (sec.)	Glaze and water (g.)	(g./sec.)
1	35.7	22.0	0.62
2	35.3	16.0	0.45
3	43.7	14.0	0.32
4	31.0	19.0	0.61
5	30.0	16.5	0.55
6	35.3	12.0	0.34
7	74.5	11.5	0.15
8	105.0	11.5	0.11−
9	49.6	12.0	0.24
10	32.1	15.0	0.47
11	41.0	14.0	0.34

Apparently there is a balance between the two end numbers which will yield a glaze of low water transmission rate (No. 7 and No. 8) because the drying time is not so much a function of the amount of water and glaze present as it is the rate at which the glaze coat transmits moisture.

The evidence points to nothing conclusive because the experiment was too limited in scope, but there must exist a *best* relation between plastics and nonplastics in any glaze to yield a glaze of fast drying properties. Excess additions of extremely fine-grained plastics *must* retard the rate of moisture transmission through the glaze film and into the ware.

Experiments no doubt will show that with the introduction of the spraying machine, on which a definite belt speed must be maintained, a much closer selection of the type and amount of plastic must be made as well as accurate control of the grinding of the glaze.

It is often advisable to heat the bisque to 130° or more to insure satisfactory drying on spray machine belts. When this is insufficient, the specific gravity is increased and deflocculation is used to reduce the water content.

II. Principles Underlying Application of Glazes for Single-Fired Ware

In compounding glazes for single-fired ware, the choice and limits of plastic content are of equal importance to the empirical glaze formula selected, and the proper selection of the plastic ingredients is considerably more important than is the case with glazes applied on semivitreous bisque. This is true particularly when glazes are applied on clay bodies of light cross-section.

It has often been found advisable in plant work to carry clay contents as high as 18 and 20% of the total batch, but to accomplish this successfully, all clay content of more than 14% should generally be introduced as an equivalent of calcined clay (usually a white firing china clay fired to cone 10 maximum). The amount of such calcined clay to be added will vary with the body to be glazed, because some clay bodies show little swelling of the outside layers when dipped; others show an excessive swelling when the moisture migrates from the glaze layer into the body. A proper adjustment of the ratio of raw clay to calcined clay will reduce the tendency toward high dipping viscosities which promote splitting of the wall of the ware when moisture penetrates both sides simultaneously. Extreme care must also be exercised to maintain the proper relation between coarse- and fine-grain sizing in grinding, so that peeling of the glaze will not result when the glazed article is dried preparatory to firing. The percentage of various grain sizes present may be controlled by selective grinding of the glaze materials instead of grinding all the materials for the maximum number of hours. By this method of grinding, glazes which present serious difficulties in the dipping operation are rendered practical and require little attention.

In many plants, where small orders are glazed at one time and the colored glazes are kept in storage for weeks at a time, the dipping properties of the same glaze are never quite the same and the variation in those properties is a function of the time left in storage. Some glazes become very viscous, resulting in streaked ware; some become gummy; and others become increasingly mobile. These changes may be attributed partly to bacterial action, but this is not always the case; occasionally the changes are caused by the slow solution of relatively low solubility materials. In the average plant where single-

* Paper No. 27 of the Glaze Symposium discussions. Received April 12, 1938.

fired ware is made and these extremely variable conditions exist, it is impractical to run a laboratory check on 10 or 15 different colored glazes each day. A simpler method of adjustment, usually performed by the foreman, is described, which yields quick and fairly reliable results.

Standard solutions are made up of soda ash, sodium silicate, ammonium oxalate, calcium chloride, Epsom salts, sulphonated castor oil, Areskap, C_2 deflocculant, aluminum chloride, gum arabic, and lime water. No single reagent suffices to produce the desired result on all glazes; *e.g.*, sodium silicate, used to reduce the viscosity of a glaze containing bentonite, gives the reverse effect and the glaze becomes badly jellied. Usually small additions of silicate of soda will deflocculate many glazes of the single-fire type, but the chief objection to its use appears to be its progressive action, and then only to flocculate.

The action of ammonium oxalate is temporary and continues only as long as the odor of ammonia can be detected rising from the surface of the glaze. Apparently its maximum effect is obtained almost immediately, but a greater amount is required to produce a given reduction in viscosity than is true of some of the other deflocculants.

Epsom salts, calcium chloride, aluminum chloride, and lime water are seldom used except on colorless glazes, which are usually applied at relatively low specific gravities.

The use of deflocculants in colored glazes enables the operator to regulate the drain and flow of the glaze from the clayware and influences the rate at which the water passes from the glaze layer into the clay wall.

When difficulty is encountered in the form of wall-splitting in dipping thin-walled clayware, the trouble can often be corrected by raising the specific gravity of the glaze and deflocculating quite strongly to a degree just short of that point at which rapid settling of the nonplastics begins.

In a single-fire production of light green glazes, it becomes imperative to glaze quite heavy to obscure or mask the objectionable brownish-green contact film formed at the body-glaze line. This unattractive color is the usual result of the action of chrome-bearing glazes on uncombined clay. It then becomes necessary to raise the glaze gravity much higher and to deflocculate to a point just short of rapid settling. The percentage of stain present in the glaze in this case is abnormally high, and the desired opacity and color are obtained by an arrested heat reaction in which color particles are left out of solution and suspended in the glass. Calcination of such light green stains to a point approximately four cones lower than the point of glaze maturity materially improves the color and opacity of the resulting light green glaze.

The relation of thickness of glaze coat to the properties of ware in service is fairly well known, but the difficulties encountered in the kiln caused by heavy glazing of single-fired ware are not so well understood. Many glazes, applied in thin layers, offer no problems, but when the same glaze is applied quite heavy, problems of glaze fit and body fit throughout the shrinkage stage become more acute. Any slight difference between the shrinkage of the body and that of the glaze coat causes blistering on sharp corners, a defect especially common with glazes having a viscous character at the point of maximum kiln temperature. When broken, such blisters reveal the fact that the glaze and body parted company before the ware reached the fire zone of the kiln. The obvious remedy is to introduce in the glaze formula a small percentage (usually 2 or 3%) of an early-melting compatible frit which holds down the glaze layer to the body during the shrinking stage and whose action is mechanical. Naturally such a frit must not interfere with the evolution of gases from the oxidation of organic materials in the clay body, *i.e.*, introduction of such frit may result in body blisters if the percentage used is excessive.

HALL CHINA COMPANY
EAST LIVERPOOL, OHIO

ELIMINATION OF GLAZE DEFECTS BY CONTROL OF THE GLAZE CONSISTENCY*

By W. R. Morgan and W. B. McDevitt

I. Introduction

In laboratory studies of experimental glaze fields or in the limited production of commercial ware, there is little opportunity to work out a satisfactory procedure for the application of each individual glaze. As a result, glazes may be improperly applied, and too frequently glaze defects which appear on the finished ware are attributed to the glaze composition rather than to the faulty application. In well-controlled commercial production, such difficulties need not arise, and even in more or less uncontrolled production they usually are gradually worked out by the expensive trial-and-error method. In a good many cases, glazes are set at dipping consistency by "feel" by the dipper, or a simple control may be used by determining the specific gravity of the dipping glaze. Although the latter may suffice in some cases, the method is not always satisfactory because the consistency or dipping characteristics of a glaze of given composition and specific gravity can be altered appreciably by temperature, clay content, solubility of glaze constituents, electrolyte additions, and by many other factors.

Most of the published experimental work on control of consistency has been done in the enameling industry. The studies which have been carried out have been concerned with the ease and perfection of application and the weight or thickness of enamel retained on the surface of the ware. The problems of consistency control have been approached by studies of the effect of such factors as clay content, water content, electrolyte additions, temperature, and fineness of grind on the mobility, yield value, draining time, and weight of enamel retained on the surface of the ware. In the final analysis, in addition to the ease and perfection of application, the object of consistency control is to control the weight or thickness of the coating applied to the ware.

II. Purpose

The purpose of the present study was to vary the consistency of a given glaze in the simplest manner, *i.e.*, (1) to change the water content to determine the effect of changes in consistency on the weight of adhering glaze by the most direct method, (2) to weigh the ware before and after dipping, and (3) to correlate the appearance of glaze defects on the finished ware with the weight of glaze applied and thus demonstrate the importance of the control of glaze consistency.

III. Procedure

A set of specimens, consisting of sixty-six bowls, was made by jiggering, using washed Whitehall stoneware clay. The bowls were dried and finished in the usual manner and were fired to cone 5. The percentage absorption of each fired bowl was determined after saturating with water by immersion in a vacuum chamber in which reduced pressure of approximately 20 mm. of mercury was maintained for a period of 12 hours. The bowls were then separated into three groups, in each of which the absorption ranged from the minimum to the maximum values.

* Paper No. 5 of the Glaze Symposium discussions. Received March 31, 1938.

The bowls were dried and allowed to cool to atmospheric temperature. Each of the three groups of bowls, varying from low to high absorption, was dipped in a raw lead glaze, the consistency of the glaze being altered for each group by the addition of water. In this manner, heavy, medium, and light dips were obtained on similar groups of bowls in which the absorption varied approximately from the minimum to the maximum value. The water content, specific gravity, and relative viscosity of each batch of glaze were determined for comparison with the weight of glaze retained by the ware.

Glaze Composition and Properties

$$\left.\begin{matrix}0.055\ K_2O \\ .048\ Na_2O \\ .105\ CaO \\ .003\ MgO \\ .092\ ZnO \\ .698\ PbO\end{matrix}\right\}\ 0.152\ Al_2O_3 \quad 1.41\ SiO_2$$

	Glaze used for		
	Heavy dip	Medium dip	Light dip
Water (dry basis) (%)	57.8	67.0	77.0
Specific gravity	1.93	1.83	1.74
Relative viscosity	2.85	2.24	1.99

The bowls, which were then dried and weighed to determine the amount of glaze which had been taken up, were again separated into three groups by taking every third bowl in each of the heavy-, medium-, and light-dip groups, so that each of the three final groups contained bowls varying in absorption from the minimum to the maximum value and covered with heavy-, medium-, and light-glaze coatings. The final groups of bowls were fired to cones 02, 01, and 1, respectively, in individual lead-washed saggers with cones in each sagger for a further check on the firing temperature. The kiln temperature was increased at a rate of 50°C per hour up to 1000°C, above which temperature the rate was retarded and the kiln was given a soaking finish.

IV. Results and Discussion

The results are shown in Fig. 1. The extreme variation in absorption was from a minimum of 6.5% to a maximum of 11.6%; the average for the entire group was about 8.5%.

The minimum weight of glaze taken up was 9.40 grams for a hard bowl with a light dip, and the maximum weight taken up was 42.45 grams for a soft bowl with a heavy dip.

The temperature distribution in the various saggers was not uniform so that considerable variation occurred in each firing. In general, however, running of the glaze was severe on all of the heavy-dipped bowls in all three tests; running was slightly less severe on the harder bowls because of the thinner coating. On the medium-dipped bowls, there was no visible evidence of running in any of the three firings, except in two random cases and in the case of the softest bowls which had the thickest coatings. On the light-dipped bowls, there was no running of the glaze in any of the tests except in one isolated case.

All of the heavy-dipped bowls blistered, except a few of the harder bowls with the thinner coatings. On the medium-dipped bowls, none but the softest blistered at cone 02. At the two other firing temperatures, blistering occurred more or less indiscriminately. None of the light-dipped bowls blistered at any of the three temperatures.

All of the heavy-dipped bowls crazed, the action being delayed in the case of the harder bowls with the thinner coatings. The harder bowls with medium dip did not craze, but crazing increased with increasing softness of the bowls. The harder bowls with the light dip did not craze at cone 02; only one underfired bowl crazed in the cone 01 test, and only the softest bowls with light dip crazed at cone 1. In general, crazing was less severe as the hardness of the bowls increased, in that crazing either failed to occur or was delayed. Increase in the firing temperature of the glaze decreased the tendency of the glaze to craze.

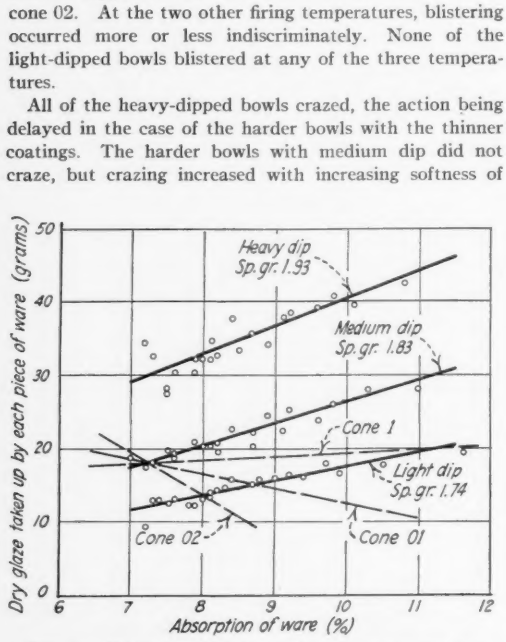


FIG. 1.—Effect of specific gravity of glaze and percentage absorption of ware on weight of glaze taken up and on the resulting quality of the glaze (no running, blistering, or crazing below broken lines at cones given).

The rims of the bowls were smooth for all heavy-, medium-, and light-dipped ware fired at cone 02; the heavy-dipped bowl rims were smooth, and about half of the rims of medium- and light-dipped bowls were rough at cone 01. All of the bowl rims were smooth at cone 1, except the hardest of the light-dipped bowls. The absence of roughness may be attributed to the fact that the actual firing temperature was such that the flow of the glaze was not sufficient to reduce the glaze thickness on the rims.

As shown in Fig. 1, if the weight of the glaze taken up exceeded about 15 grams per bowl, one of the defects was almost certain to appear unless the bowl was quite hard, as indicated by an absorption of 7.0 to 7.5%. If the bowls were hard, the maximum allowable weight of glaze could be increased to 18 grams per bowl without the appearance of defects. The minimum weight taken up by any bowl was 9.40 grams, which gave a slightly rough finish not only on the rim but on the sides, although the latter seemed to be caused at least partly by excessive sponging during finishing. To eliminate dryness from too light a glaze and crazing of soft-fired bowls because of heavy glaze, it seems probable that the minimum and maximum weights of glaze for the particular glaze and ware used should be set at 10.0 and 15.0 grams, respectively.

V. Conclusions

Nonuniform firing of the bisque ware will cause unequal weights of glaze to be taken up by the ware even though the properties of the glaze are kept constant. Likewise, even with uniform bisque ware, variation in the consistency of the glaze will cause unequal weights of glaze to be taken up by the ware. In both cases, excessive weight of the glaze may produce defects in the finished glaze which can be eliminated by reducing the thickness of the glaze coating and are not related to or attributable to faulty glaze composition. Control of glaze consistency then is an important factor in the elimination of glaze defects.

DEPARTMENT OF CERAMIC ENGINEERING
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

TRANSFORMATION POINT OF GLAZES*

By F. H. Norton

The exact nature of the transformation point in a glass or glaze is not as yet definitely established, but some experimenters believe that it represents the boundary between the solid and the liquid state. In its relation with glazes, however, it is known definitely that there is a marked change in the coefficient of expansion at the transforming temperature. There is, for example, a fairly uniform expansion coefficient from room temperature to the transformation point, and then another and much higher coefficient of expansion from the transformation point to the softening point. In cooling a glazed piece, the stress developed in the glaze will therefore be more or less proportional to the differences in total contraction of glaze and body from the temperature in which the glaze becomes rigid enough to support stress at room temperature. For fairly rapid cooling, this temperature may lie somewhat above the transformation point so that the primary coefficient of expansion and also the secondary coefficient of expansion have been accounted for. It is also evident that a change in composition of the glaze which will increase the temperature of transformation may actually reverse the final stress in the glaze without changing the primary coefficient of expansion. This explains why a change is often made in the glaze to decrease crazing, and later it is found that the trouble has not been corrected

This effect of secondary expansion was first pointed out by Benrubi,[1] who showed the importance of considering the secondary expansion on glaze stresses. In determining this second expansion, there are a number of necessary precautions. In the first place, the measurement of thermal expansion must be made in a furnace where the temperature is uniform over the length of the specimen, and the specimen must be tested while it is free from stress in order to give a sharp transformation point. Many previous tests which have been made on specimens under stress have not shown the transformation point clearly. It should also be realized that the composition of the glaze after firing on the body, is by no means the same as the composition of the same glaze melted in a crucible.

Massachusetts Institute of Technology
Cambridge, Massachusetts

* Paper No. 5 of the Glaze Symposium discussions. Received March 30, 1938.

[1] J. H. Benrubi, "Agreement of Bodies and Ceramic Glazes," *Verre et Silicates Ind.*, **7** [6] 61–65; [7] 73–77; [8] 90–93 (1936); *Ceram. Abs.*, **15** [7] 211 (1936).

MEASUREMENT OF KIND AND DEGREE OF STRESS EXISTING BETWEEN GLAZE AND BODY*

By F. H. Norton

The stress in a glaze when applied to the body can be measured in a number of ways. Schurecht developed methods whereby the relative amount of stress in a glazed ring could be easily determined. In Germany, Steger developed a method whereby the stress could be measured on a glazed bar during the whole cooling cycle. More recently, a method has been worked out in this laboratory whereby the specimen, in the form of a tuning fork, is glazed on the outer sides of the prongs and is allowed to cool in a special furnace, the stress in the glaze at any time being measured by the relative distance between the tips of the prongs. This is a sensitive method, and the specimen can be removed from the furnace for aging or for running in the autoclave without disturbing the equilibrium. It is also possible to measure the stress in the body by grinding a thin section perpendicular to the surface and to determine the glaze stress by elastic methods, using the polarizing microscope.

In general, craze-free glazes are not in tension because the glaze itself can not support any appreciable tension without showing crazing. On the other hand, quite high compressions can be reached in a glaze without shivering. Values of compression as high as 8 kg. per sq. mm. have been measured in a glaze soon after cooling. This compression, however, decreases with time owing to the after-contraction of the glaze, and still more if there is any moisture expansion of the body. A high initial compression is therefore necessary in a stable glaze.

Massachusetts Institute of Technology
Cambridge, Massachusetts

* Paper No. 14 of the Glaze Symposium discussions. Received March 30, 1938.

SOFTENING POINT OF GLAZES*

By Arthur S. Watts

I. Effect of Frit Composition and Firing Temperature on Character and Properties of Dinnerware Glazes

This study was undertaken to show whether the properties of a glaze are different when all of the lead or only a small proportion of the lead is fritted.

The glazes studied were as follows:

(1A) Low lead glaze (33% lead in frit)

Glaze formula

$$\left.\begin{matrix}0.18\ PbO\\ .14\ Na_2O\\ .07\ K_2O\\ .48\ (CaMg)O\\ .13\ ZnO\end{matrix}\right\}\ 0.27\ Al_2O_3\left\{\begin{matrix}2.6\ SiO_2\\ 0.36\ B_2O_3\end{matrix}\right.$$

Frit

$$\left.\begin{matrix}0.06\ PbO\\ .06\ Na_2O\\ .03\ K_2O\\ .24\ (CaMg)O\end{matrix}\right\}\ 0.09\ Al_2O_3\left\{\begin{matrix}0.72\ SiO_2\\ 0.36\ B_2O_3\end{matrix}\right.$$

(1B) Low lead glaze (all lead in frit)

(Glaze formula same as (1A))

Frit

$$\left.\begin{matrix}0.18\ PbO\\ .06\ Na_2O\\ .03\ K_2O\\ .24\ (CaMg)O\end{matrix}\right\}\ 0.09\ Al_2O_3\left\{\begin{matrix}0.72\ SiO_2\\ 0.36\ B_2O_3\end{matrix}\right.$$

(2A) Medium lead glaze (20% of lead in frit)

(Typical throughout semiporcelain industry)

Glaze formula

$$\left.\begin{matrix}0.26\ PbO\\ .06\ Na_2O\\ .12\ K_2O\\ .43\ CaO\\ .13\ ZnO\end{matrix}\right\}\ 0.27\ Al_2O_3\left\{\begin{matrix}2.6\ SiO_2\\ 0.31\ B_2O_3\end{matrix}\right.$$

Frit

$$\left.\begin{matrix}0.050\ PbO\\ 0.028\ Na_2O\\ 0.031\ K_2O\\ 0.357\ CaO\end{matrix}\right\}\ 0.059\ Al_2O_3\left\{\begin{matrix}0.838\ SiO_2\\ 0.310\ B_2O_3\end{matrix}\right.$$

(2B) Medium lead glaze (all lead in frit)

(Glaze formula same as (2A))

Lead frit

$$\left.\begin{matrix}0.26\ PbO\\ 0.05\ CaO\end{matrix}\right\}\ 0.075\ Al_2O_3\quad 0.612\ SiO_2$$

Leadless frit

$$\left.\begin{matrix}0.06\ Na_2O\\ .12\ K_2O\\ .06\ CaO\end{matrix}\right\}\ 0.10\ \ Al_2O_3\left\{\begin{matrix}0.75\ SiO_2\\ 0.31\ B_2O_3\end{matrix}\right.$$

(3A) High lead glaze (35% lead in frit)

Glaze formula

$$\left.\begin{matrix}0.34\ PbO\\ .07\ Na_2O\\ .14\ K_2O\\ .35\ CaO\\ .10\ ZnO\end{matrix}\right\}\ 0.27\ Al_2O_3\left\{\begin{matrix}2.60\ SiO_2\\ 0.20\ B_2O_3\end{matrix}\right.$$

Frit

$$\left.\begin{matrix}0.12\ PbO\\ .03\ Na_2O\\ .06\ K_2O\\ .12\ CaO\end{matrix}\right\}\ 0.09\ Al_2O_3\left\{\begin{matrix}0.72\ SiO_2\\ 0.20\ B_2O_3\end{matrix}\right.$$

All frits were fused as quickly as possible in preheated crucibles and poured into water. The glazes were ground in ball mills for 8 hours and applied to biscuit earthenware trials with 8% absorption at 1.55 sp. gr. On the biscuit porcelain trials, the glazes were thickened with small additions of gum arabic. The glazes were fired for 24 hours at a variety of temperatures from cones 3 to 6; they were cooled for 16 hours.

If all the lead salts are fritted, the temperature of initial fusion and of deformation is raised and is more pronounced with increase in lead content. This is supported by observations of the glaze applied to ware.

* Paper No. 6 of the Glaze Symposium discussions. Received March 31, 1938.

Data on Softening Points of Glazes

		1A	1B	2A	2B	3A
Standard 3-faced cone (2.375 in. high by 0.3 in. face)	Start (°F)	1540	1590	1510	1610	1250
	Down (°F)	1640	1660	1530	1650	1420
True cone (1.625 in. high by 1.0 in. diameter)	Temp. (°F)	1640	1660	1530	1650	1420
	Height (in.)	1.125	1.06	1.11	1.03	Bloated
Hemisphere (0.5 in. high by 1.0 in. diameter)	Temp. (°F)	1640	1660	1530	1650	1420
	Height (in.)	0.50	0.44	0.47	0.48	Bloated
	Diam. (in.)	0.97	0.94	1.06	1.016	Bloated
Standard flow wedge	Temp. (°F)	1640	1660	1530	1650	1420
	Flow (in.)	0.047	0.25	0.56	0.625	0.187

II. Hardness Measurements on Glazed Surfaces of Various Compositions and Fired at Various Temperatures

This test was made by the loaded diamond-point technique; constant load 100 grams and rate of travel 3.88 in. per hour; values in width of scratch (mm. $\times 10^{-3}$).

Glaze No.	Cone temp.	Semivitreous china biscuit			Vitreous china biscuit		
		Max.	Min.	Av. 15 tests	Max.	Min.	Av. 15 tests
1A	3[6]	30.73	28.79	30.03	28.35	26.35	27.09
1A	5[6]	26.07	24.66	25.05	25.93	23.99	24.75
1B	3[6]	30.57	29.23	29.75	27.64	25.07	26.32
1B	5[6]	25.01	23.97	24.34	27.01	23.62	25.31
2A	3[6]	33.24	30.09	31.05	32.83	29.65	31.19
2A	5[6]	28.21	26.99	27.85	30.23	28.15	28.44
2B	3[6]	32.76	29.05	30.87	30.23	28.75	29.44
2B	5[6]	28.35	26.88	27.16	28.91	26.90	27.98
3A	3[6]	35.11	30.96	33.68	34.00	30.60	32.33
3A	5[6]	29.03	27.64	28.79	28.95	27.02	27.88

(1) Analysis of Data

(1) Increased lead content in the glaze results in decreased resistance to scratch.

(2) Incorporation of all the lead in the frit slightly increases the resistance to scratch.

(3) Increase of firing temperature from cones 3[6] to 5[6] increases resistance to scratch to a marked degree both in the glazes which contain some raw lead and in those containing only fritted lead.

Semivitreous china biscuit and vitreous china biscuit were used in these tests.

(2) Conclusions

The use of a mass of the glaze formed into a true cone, a solid cylinder, or a hemisphere is not a satisfactory test for the glaze softening temperature, and the wedge used to study feldspar fusion is equally unsatisfactory. The standard three-sided cone of smaller cross-section gives much more definite deformation values.

Progressive maturity may be shown by applying the glaze to standard semivitreous or vitreous biscuit trials and firing at progressive temperatures. If these trials are sloped at a given angle, the tendency to flow is clearly evidenced, although this probably could not be expressed in mathematical values. The scratch-hardness test, however, should indicate the temperature necessary to produce the best properties in the glaze without objectionable flowage or evidence of overfiring.

Department of Ceramic Engineering
Ohio State University
Columbus, Ohio

INTAGLIO PRINTING IN THE DINNERWARE INDUSTRY*

By G. H. Stapleford

I. Introduction

Intaglio printing is a process of taking impressions in ink from engraved copper plates or cylinders. These impressions may be in the form of transfers or a completed print. The former is used for imprinting designs on tableware, the latter in printing bank notes, formal greeting cards, etc.

(1) History

Intaglio printing was first adapted for pottery decoration in 1752 by Sadler and Green in England. Josiah Wedgwood sent his bisque ware to Liverpool by pack mule to be printed and then returned for subsequent glazing and firing in his kilns.

This process was employed in making the "Staffordshire blue ware" exclusively for the American market. Enterprising English potters of that period sent their best artists to this country to paint and record pictorially interesting scenes of contemporary life in America which were then engraved on copper plates. Because this famous ware records pictorially early life in America and was designed and decorated by renowned English potters, it is highly prized by collectors of antique chinaware.

The famous "Blue Willow" pattern is a typical example of intaglio printing. The original plate was cut or engraved by Thomas Minton, who later founded the Minton China Works, of Stoke-on-Trent, England. Since that early time this pattern has been reproduced by nearly every tableware manufacturer, and it is still being printed today.

Of late years, several leading manufacturers of semivitreous ware in the United States have been successful in converting this costly process into a practical method for the mass decoration of their product. This success has been due (1) to the innovation of new methods of making the engravings by etching, (2) to new machinery for printing, and (3) to new methods of shop management.

II. Brief Outline of the Process

Intaglio printing differs from other methods of printing, such as relief or planographic printing, in that the design, pattern, or lettering is sunken or engraved into the printing form. By virtue of this one distinctive feature, it is possible to get a heavy and variable body of color on the completed print, not possible with other styles of printing, where the impression is obtained by mere contact with the surface of the raised design.

The design is first cut into the copper plate by skilled engravers, with special tools; this removes slivers of the metal, leaving small grooves or troughs into which the ink or color is pressed when printing. Thus, the deeper the engraving is made, the more ink can be pressed into it. Through suitable means, usually by a hand press or rubber roller, the thin tissue or impression paper is forced onto the inked engraving. When the paper is removed, it brings the ink with it because the paper presents a greater adhesion than the metal. The finished print will show the design in relief or embossed.

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 29, 1938 (Art Division). Received March 24, 1938.

Another radical difference between intaglio and other methods of reproduction is that the oil colors used must be kept warm during the printing operation because a heavy viscous varnish is used and the addition of heat assists in manipulation. The prints or "transfers" are transferred to the ware and are rubbed with stiff-bristled brushes to insure that every part of the design adheres to the surface. The paper is then washed away leaving the printed design intact on the ware.

III. Hand-Press Printing

The hand press is an early type of machine used for intaglio printing. It is simple in construction, consisting mainly of two large iron rollers, 12 by 18 inches, one set above the other in a strong cast-iron frame. Between the two rollers is a large iron flat plate or bed (36 by 18 inches) upon which the copper plate rests when the print is being pulled. Two or three thicknesses of flannel are fastened around the top roller to assist in forcing the paper into the recesses of the engraving. The bed is made to travel under the rollers by a long handle secured to the spindle attached to the top roller.

A stove supplies the heat required for manipulating the printing ink. This usually consists of a flat iron plate, under which are 2 or 3 gas burners. The copper-plate engraving is placed on the stove to warm before filling the engraving with ink. The ceramic colors are also ground in the sticky oil* on this stove or on a supplementary iron plate, known as a "batstone."

The paper, cut to the required size, is coated with a soap solution made by boiling one pound of English soft soap with one tablespoonful of sal soda in one gallon of water.

When the plate is warm enough, a little ink or color is worked into the engraving with a wooden muller. The surplus is removed by scraping the face of the plate with a large strong spatula, finishing with a small hand-cushion made from corduroy cloth, called a "boss." A sheet of the wet-coated tissue is laid over the plate, and both are subjected to pressure from the press. It is turned about to insure all parts of the plate receiving pressure.

The heat of the plate rapidly dries the paper, which can be removed easily and is ready for transfer to the ware.

IV. Machine Printing

(1) The Machine

There are two types of machines in use at the present time, different in construction but their action is similar. One has been patterned after the old hand press, the other has the appearance of a machinist's lathe.

The engraved cylinder is fastened in the machine by two movable chucks, which when brought together grip the cylinder. It is turned by an electric motor attached to a suitable reduction gear. Heat for printing is provided by an electric element placed inside the cylinder and connected to a rheostat on the frame of the machine.

The inking and subsequent clearing of the face of the engraving is performed by a long, thin blade of specially hardened steel held tangent to the length of the cylinder by severe pressure. Fracturing of this knife is prevented by the addition of another blade of heavier steel inserted at the back in the knife holder. This is known as the "stiffener." Extreme care is necessary in setting the knife for printing.

Immediately below the cylinder is a large rubber roller; this is adjustable, and its function is to force the printing paper into the engraving. The edge of this roller must be in perfect alignment with the length of the engraved cylinder or the paper will crease.

The impression paper is fed from a roll at the rear of the machine. This roll is held rather loosely on a spindle. Its tendency to over-run printing speed is retarded by weighted straps of leather hung over part of its circumference. In machine printing, the paper is not generally sized as in hand-press work, because sizing distorts the paper as it comes through pressure, and it is hopelessly creased.

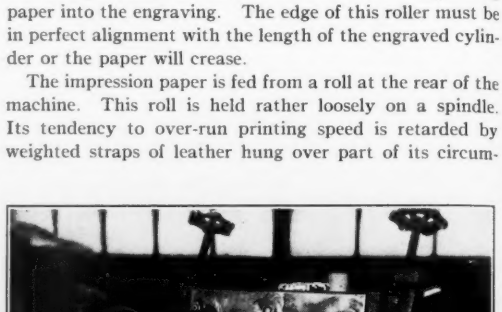


FIG. 1.—Close-up of engraved cylinder on machine, with doctor knife positioned ready for printing. All engraved rollers are plated with steel to protect the copper from scratches.

(2) Printing Oil

This substance has been the subject of bitter controversy in the past, because each printer took a personal pride in manufacturing it from the raw materials. It is prepared from boiled linseed oil, and other ingredients are added during the boiling and cooling. Boiling linseed oil in a limited space or room is a dangerous business, because it is inflammable. The fumes are extremely pungent and offensive to some people. An old periodic kiln is an ideal place to prepare printing oil.

The following is a typical recipe: 1 gallon of best refined linseed oil, 2 pints of rapeseed oil, and $1^1/_2$ to 2 ounces of red lead. These are boiled together for at least three hours, or as long as required to make it fairly stiff. While cooling, add 12 ounces of best pine tar oil.

V. Machine Management

It is the printer's job to set the machine, to grind the colors in the oil, and also to take care of plating jobs if equipment is provided for that purpose. Although the grinding of the color is sometimes given over to a helper, it is advisable for the printer to oversee this operation.

* Described in Section IV (2).

(1) Care of the Knife

In underglaze printing, the edge of the printing knife is soon lost, owing to the abrasive action of these colors. This is annoying, but it is unavoidable in machine printing; the work must be stopped to remove the color from the machine and to reset the edge. The knife is removed from the machine, placed in a suitable holder or vise, and the edge is filed at right angles to the width of the knife. This edge has to be perfectly flat (not rounded). Resetting of the knife in the holder is checked with a fine measuring rule to insure the correct distance from the roller.

(2) Impression Roller

Little trouble is occasioned from this roller, when properly adjusted. Too much heat in printing, however, tends to impair its function by creating a glaze on the surface. Bad cases may be remedied by refacing in a machinist's lathe. This is done by placing a fairly coarse file tangent to its surface to allow the roller to revolve at slow speed. Such a remedy is severe and is usually a last resource.

Success in printing depends chiefly on careful adjustment of the knife and proper mixing of the color in the oil. All the colors should be well lawned and, if at all coarse, they should be reground in a pebble mill. For machine printing, the color is mixed as stiff as possible. The mixing of the color in the oil is done first on the stove using a gentle heat; the whole mix is then transferred to a wet mill, under which some arrangement is made for heat.

VI. Transferring

Like most other branches of the process, this work has been lightened by the rubbing-down machines. The print is cut from the paper as it is received from the printer and placed into position on the ware. All creases are avoided as far as possible, although some will occur on irregular-shaped pieces, such as hollow ware. Soft soap or glycerin is used as a lubricant in the rubbing down.

It is customary for the ware to stand for about an hour before the paper is washed off, so that the ink or oil can be absorbed. In overglaze work, the color is allowed to harden before removing the paper.

When the ware has stood for some time, it is placed in a circular machine through which water is sprayed by gravity. Obstinate sticking of the paper often means that the ware has stood too long before washing off, and the oil itself has started to dry and stick to the tissue. In hand-press printing, where the tissue paper is coated with a size, this difficulty is not encountered.

No size is used in machine printing because of paper creasing on the roller. All finger marks on the ware can be removed by using an ordinary stenographers' eraser.

(1) Plucking and Dusting

Some years ago, this method of printing was used for overglaze work. The print was laid on the ware, rubbed down, and the paper was forcibly removed without wetting. The impression left was then dusted with the color. This method was used for gold printing, but is seldom used today.

VII. The Engraving Department

(1) The Metal

Copper is the universal metal used for pottery intaglio printing because it holds the ink warmer for a longer period than steel; the latter, however, is often used in other industries.

Only the best copper is considered, and it is usually bought from ceramic color supply houses. This applies both to the flat copper plates for hand-press work and copper cylinders for machine printing. If the cylinders are bought elsewhere, they should be tested for hardness and consistency in diameter. There should be no taper along the length of the cylinder.

All the metal is usually supplied highly polished for the engraver. It should be inspected by the engraver however, for any chance scratches, because they can not be removed or altered without ruining part of the work.

(2) The Designs

In pottery operations, it is customary for the proposed design to be first drawn in water-color on a sketch-board. From this, the engraver must revise it to fit the various pieces that comprise a set of dinnerware. These redrawings are called "strikes" and remain as pencil sketches. Tracings are made and traced down on to the copper with stenographers' carbon paper. This work is called the "lay-out." For cylinder work, the straight lines of the pattern must not run parallel with the edge of the printing knife or the latter will surely cause damage to the engraved portion.

(3) Cutting the Pattern on the Copper

Tools, known as "gravers" and "punches," are used by the engraver. Other tools are supplementary. Gravers are long slender lengths of specially hardened steel, four-sided, and slightly curved to admit clearance in the cutting. One end is tapered to fit into a small handle and the other end is sharpened to provide a cutting edge. It is pushed along the lines of the pattern which removes small slivers of the copper. Any burr formed is removed by a steel chisel.

The heavy shades of the pattern are represented on copper by engraved cross-hatched lines. This cross-hatching leaves minute "hills" of the copper standing up. These "hills" play an important part in the printing because they prevent the knife of the machine from entering too deep and removing too much ink, which would destroy the function of the cross-hatching, that is, to represent the heavy tones of the pattern.

The light tones of the design are represented on copper by a series of small holes punched in the metal. These are made by a punch which is struck by a small well-balanced engravers' hammer. The dots may run in lines to emphasize the modeling of the tones or they may be laid in flat tones as the case may be.

Variation of tone can be obtained by cutting and punching deeper as required. It takes many years of patience and art ability to become a proficient engraver, and pottery engravers are specialists in their line.

VIII. Etching

Copper etching is largely replacing hand engraving because it is much quicker. Although it is satisfactory for

some types of patterns, it is not so good as a hand-engraved plate, chiefly because of the difficulty in obtaining full printing from the engraving. The cost has been found to be about the same for an etched plate or roll as for a hand-engraved job. In semivitreous work, where time is a pertinent factor, etchings are preferred in spite of their many handicaps. Good results have been obtained, and designers have attempted to eliminate a good many of the drawbacks by adjusting the patterns and subsequent drawings to suit the process.

Some etchings are made by an iron perchloride solution and some by electrolysis. The latter has a much faster "bite" than the former. The plate is covered with a resist except where the design occurs. The method generally employed today is the photoengraving process, which is described as follows:

The copper plate or roll is coated with a solution made from photoengravers' glue, egg albumen, and ammonium bichromate. The film thus formed becomes insoluble in liquids when exposed for some time to light; subsequently it becomes the ground for a resist or it makes a suitable resist by itself when baked on the roll.

Before exposure to light, a photofacsimile of the drawing is placed into firm contact with the plate. This facsimile prevents the light from reaching the parts intended for imposition of the design. Thus when exposure is complete, these same parts remain soluble and can be washed away with warm water, leaving the design exposed.

After baking, or covering with a further protecting resist, the plate or roll is placed in the etching bath for a prescribed time. The lightest parts are painted in from time to time with a resist, and the heavier portions are given a longer time in the bath. When complete, the roller or plate is cleaned and plated with steel.

One of the greatest drawbacks in etched work has been the tendency of the etching process to "undercut" the work, preventing the ink from being lifted in the printing. There appears to be no cure for this, but some plants have used only half the etch and have employed a hand-engraver to complete the work. This is an ideal solution to the present problem and gives the advantages of both methods.

Bibliography

(1) W. Burton, Josiah Wedgwood and His Pottery. Cassell & Co., Ltd., London, England (limited ed.), 1922. 196 pp.
(2) N. Hudson Moore, Old China Book. Tudor Publishing Co., New York, N. Y. (new ed.), 1935. 300 pp.
(3) Ada Walker Cammell, Blue China Book. E. P. Dutton & Co., New York, N. Y., 1916. 300 pp.

117 Thompson Avenue
East Liverpool, Ohio

THE MANUFACTURE OF PORCELAIN NEAR TEHWA, SOUTH CHINA *

By Willard J. Sutton

Abstract

Tehwa was the most famous center for the production of *blanc de Chine* during the Ming and Ch'ing dynasties, beginning in the 14th Century, and is considered to have been the second most important center in China in its influence on the work of potters in Europe and America. Owing to its inaccessibility, relatively few visitors have seen the work carried on in this old center. The processes still in use are about the same as they have been for centuries except that overglaze decoration is now quite common. The Tehwa kilns are efficient and are undoubtedly the best developed in China. The steps in manufacture are described.

I. Introduction

Long before the Middle Ages Chinese pottery was well known wherever Arab traders were found. During the early years of the 14th Century, a few choice pieces of porcelain found their way to Europe where they at once became the prized possessions of kings. Being far superior to the pottery then made in Europe, these Oriental specimens created a sensation, and since that time Chinese ceramic art has exercised considerable influence on the work of European and American potters. The universal use of the terms "chinaware" and "kaolin" pay tribute to the potters of China who first discovered the art of making hard porcelain.

Among the better porcelains produced in China is a group known as *blanc de Chine* or Chinese white. Most of this type of ware (see Fig. 1(*A*)) was produced near Tehwa (Tehua), a small city sequestered in the mountains of Fukien province, about one hundred miles inland from the port of Amoy on the South China coast. This porcelain has a fine white body, varying from ivory to a slight bluish tint, and depends for its beauty upon the superlative quality of the body and glaze, its translucency, and upon the work of artisans who have shown remarkable skill in modeling figures of Chinese deities (see Fig. 1 (*B*)). Other objects consist of many types of incense burners, libation cups, and vases. Modern Tehwa ware reproduces the older types in varying degrees of quality and includes large numbers of cheap teacups, teapots, and porcelain spoons so commonly used in China. Although some blue and white ware was produced several centuries ago in the Ming dynasty, this center was known only for its white ware, but present-day production includes many overglaze color decorations with the free use of gold. Much of this decoration consists of scenes copied from conventional Chinese paintings.

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 29, 1938 (Art Division). Received April 23, 1938.

Much of the present Tehwa porcelain is inferior to that produced from one to six centuries ago, but this city has contributed many fine pieces to the best ceramic collections throughout the world. During the Ming and Ch'ing dynasties (A.D. 1368–1912), Chinese porcelain reached its height in beauty and technical perfection. Ching-Te-Chen (King-Te-Chin) was the most prominent center in all China, but there a pallette of many colors was used in decoration, while Tehwa ware had only a plain white to rely on for its beauty. The most beautiful Tehwa figures are of Kuan-Yin, Goddess of Mercy. Burton[1] has written, "First for their delicate and exquisite beauty, we may consider the examples . . . . fashioned in pure white or creamy porcelain . . . . usually clothed with a rich white glaze, soft and tender, both to eye and to touch. Such porcelains, *blancs de Chine*, have ranked among the choicest treasures of European collectors for many centuries and have been widely imitated wherever porcelain has been made . . . . In these white figures of 'Kuan-Yin,' we find the most gracious and loving tenderness such as is only associated with happy motherhood." Burton, with many other authorities, considers Tehwa the second most important center in China in its influence on the work of potters in Europe and America.

FIG. 1.—(*A*) Typical porcelain figures on display in a Tehwa shop. (*B*) Modeling porcelain figures. (*C*) Typical porcelain-producing village.

For more than ten years, the author had planned a trip to Tehwa from Foochow, but danger from bandits and the difficulties of travel proved a successful barrier. In recent years, the Fukien provincial government has suppressed the bandits and carried out a remarkable road-building program so that it is now possible to make the trip from Foochow over a two-hundred mile motor road. Up to the present time, relatively few European or American visitors have seen this interesting and important pottery center, which has probably been in existence since some time during the Sung dynasty (A.D. 960–1279).

Our party of four started out before good bus service had been established, and so the trip required three days, the last stage of the journey being made in an open truck on a rather steep mountain road.

Tehwa is a city of about twelve thousand people located in a broad valley about two thousand feet above sea level. No porcelain kilns exist inside of the city, but the shops of decorators and of the makers of modeled figures are to be found there. It is the center of a district where a number of villages (see Fig. 1(*C*)) are engaged almost exclusively in making white porcelain. Each village is built around from one to six kilns, each containing six large compartments (to be described). The finished ware is packed with rice straw in baskets resembling the common bushel container. A man will carry two of these, hung at the ends of a bamboo stick, for many miles in a single day.

It is truly remarkable how this city, isolated in the mountains of Fukien province, could export its product on the shoulders of men, or in boats sailing down small streams, and exert so great an influence in distant lands Undoubtedly the production of ware in Tehwa is now considerably less than in past centuries, owing to the fact that bandits and communists have been active in this district in recent years and also owing to the competition of cheap Japanese soft porcelain.

Lenz[2] has given an illustrated description of the important Chinese porcelain center at Ching-Te-Chen (King-Te-Chin). Leibson[3] has also described this district and

[1] Wm. Burton, A General History of Porcelain, Vol. I, p. 26. Cassell & Co., Ltd., London, England, 1921.

[2] Frank B. Lenz, "World's Ancient Porcelain Center," *Nat. Geographic Mag.*, **38**, 391–406 (1920).

[3] J. S. Leibson, "Porcelain Making in China, a New Turn to an Old Art," *Bull. Amer. Ceram. Soc.*, **8** [6] 135–42 (1929).

has given a good outline of the modern manufacture of electrical porcelain in Shanghai. Lewis[4] has recently described the manufacture of common pottery near Canton in South China.

Owing to the fact that the Tehwa people speak the Amoy dialect, practically all conversation had to be carried on through an interpreter which made it difficult to get accurate information. The principal steps in making

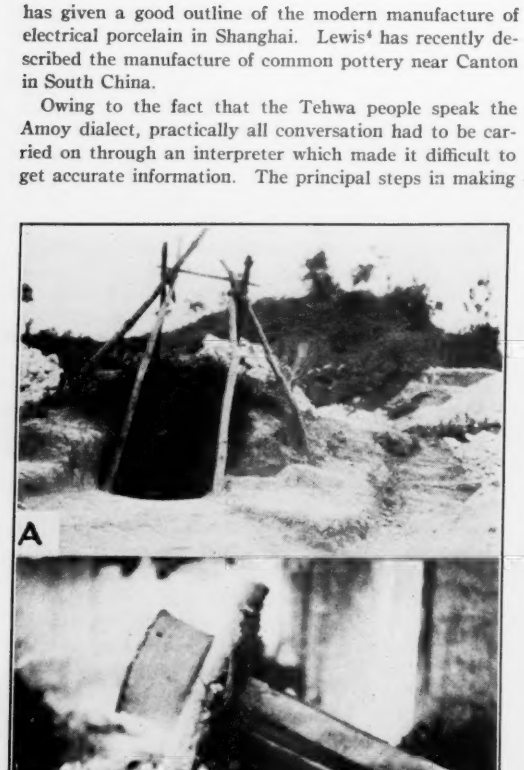


FIG. 2.—(*A*) Scene at clay mines. (*B*) Potter's wheel showing parts and construction.

porcelain as described here were obtained by direct observation and by questions asked of the potters while at work.

II. Raw Materials

The plastic clay body which is used for making porcelain is prepared by grinding and washing a grayish white weathered rock, which is apparently a natural porcelain mixture. The deposit visited was about 1½ miles from Tehwa near the top of a 400-foot hill covered with a sandy reddish-brown clay. The rock is found from 6 to 20 feet below the surface and is dug from pits and shafts (see Fig. 2 (*A*)). The rock, which is found in various stages of weathering, is sometimes piled on the ground for further weathering but is often carried in baskets directly to the streams where it is ground by water power. Softer rock, which seemed to be a partially weathered feldspar, was used for the body while the harder pieces were said to be used in making the glaze. A microscopic examination of the rock revealed but few quartz grains and a few grains of dark iron-bearing minerals.

The grinding is carried out by placing the rock under steel-tipped hammers on long wooden handles operated generally by 8-foot over- or under-shot water wheels (see

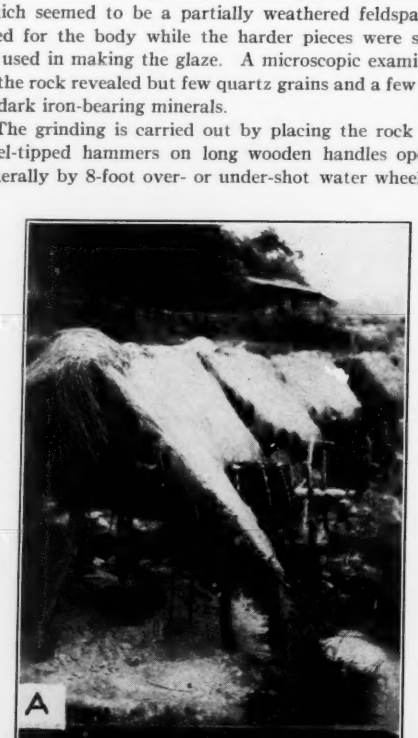


FIG. 3.—(*A*) Water mills for grinding rock. (*B*) Crude muffle kilns for firing overglaze colors.

Fig. 3 (*A*)). These mills are similar to the rice mills used in China for centuries. After many hours of pounding, the rock is stirred in nearby water pits to separate out the coarse particles for more grinding. By settling and drying, a plastic body is obtained which is ready for the

[4] Marvin O. Lewis, "Pottery Making in China," *Ceram. Ind.*, **28** [4] 347–50 (1937).

potters. Quite often the digging and grinding of the rock is carried on by local farmers not directly connected with the potteries. It is obvious that a fair percentage of the finished ware would contain iron specks owing to the ignorance or carelessness of the men who prepare the raw material. A load of about 130 pounds of rock is worth about $0.10 in Chinese currency at the pits, and a similar load of prepared body will bring $0.45 at a pottery village a few miles away. At the time, approximately one dollar in Chinese money would equal 30 cents in United States currency, so it is readily apparent that high labor costs have not yet reached China, especially in Tehwa where most commodities are still carried in baskets by men using shoulder poles.

The glaze used is applied to the unfired body and consists approximately of 1/2 ground rock, 1/4 lime, and 1/4 rice-hull ash. This rice-hull ash contains approximately 93% silica, and the combined alkalis total nearly 2.5%, the remainder being chiefly alumina, calcium, and magnesium oxides. The analysis of a typical specimen of the hard rock used for preparing the glaze is as follows:

	(%)
Ignition loss	0.93
SiO_2	76.81
Al_2O_3	12.60
Fe_2O_3	0.73
TiO_2	0.06
CaO	0.44
MgO	0.31
Na_2O	4.99
K_2O	2.85
	99.72%

It is interesting to note that the saggers and fire brick used in Tehwa are made from the common surface clays found in the region and which are fairly refractory. The brick used for building kilns are made by pounding the clay into molds which are about 9 by 14 by 4 inches.

III. The Shaping Process and the Potter's Wheel

Most of the porcelain produced in Tehwa is thrown on a wheel, which undoubtedly is similar to that used for many centuries (see Fig. 2 (*B*)). A hole is dug in the ground about three feet deep, and a pointed hardwood stake is set in it vertically with the point upward. Over this, a crude wooden wheel and framework is placed in which a porcelain cup is fastened which rests on the point of the stake and acts as a bearing. A hollow wooden sleeve extends down from the wheel and around the stake, where a porcelain ring is fitted which acts as a bearing to prevent wobble. The top of the wheel is not much more than a foot above the level of the ground, and the potter sits on a low bench (see Fig. 4 (*A*)). For making teacups, a ball of wedged clay somewhat larger than a man's head is dropped on the wheel, which is then set in motion by hand. A cup is quickly turned from the top of the piece, pinched off, and stuck on a board to dry. A bamboo stick is sometimes used to gage the width of these cups, which are remarkably thin and uniform in size and shape. After partial drying, the cups are inverted on a round knob on the wheel, and by using a bamboo splint a deep foot is turned. Incense bowls, wine pitchers, vases, and similar ware are also made on the wheel. One potter said he received 60 cents per 100 teacups thrown and that he could earn about

FIG. 4.—(*A*) Tehwa potter's wheel. (*B*) Kilns with wood and saggers stacked nearby. (*C*) Wood drying near kilns. (*D*) Overglaze decoration with pen-brush.

80 cents per day (about U. S. $0.25). Most of the teacups are made in Chinese styles without handles.

The modeled figures of Buddhas, etc., are made by pressing the plastic body in a mold of porous fired clay. Two such half molds are then joined together, forming a complete figure in which all details are put in by hand, showing delicate designs of beadwork, fingers, etc., of unbelievable fineness. These figures vary from 6 to 18 inches in height, but a few are much larger.

Porcelain spoons are made in larger numbers in porous clay molds. These are packed in layers of rice hulls which are burned and smoulder for a long time producing a soft

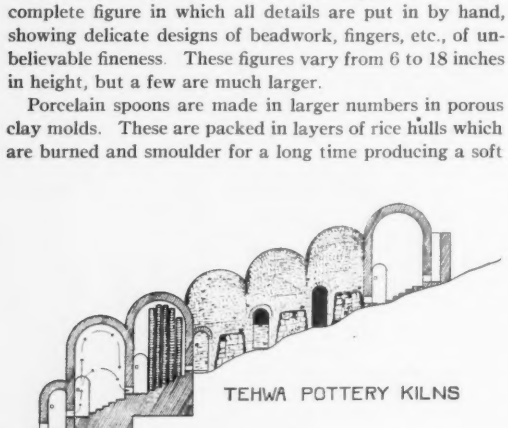


FIG. 5

biscuit ware. The ware is then glazed and fired in saggers. With the exception of spoons, practically all Tehwa porcelain is one-fire ware, where body and glaze are fired together.

After applying the glaze already described, the various types of ware are dried on boards in crude sheds, packed in round saggers from 12 to 14 inches in diameter, and stacked in the kilns. Small lumps of clay and layers of ashes prevent the glaze from sticking to the saggers.

IV. Firing

The simplest Chinese kilns are like tunnels, built up a slope to produce draft. The firing progresses from the bottom upward and small sticks of wood, grass, etc., are fed in through small openings. The Tehwa furnaces are a great improvement over this simple type (see Fig. 4 (*B*) and Fig. 5). They usually consist of 6 large compartments, each joined by about 16 openings, approximately 6 inches wide and 1 foot high at the floor level. Each compartment is about 20 feet long with an arched door at each end. The height from the lower floor level to the top of the crown is 18 feet, and the width is about 10 feet. The bottom of the kiln consists of a series of steps, 6 to 8 inches high, running across the kiln from door to door. These are about 15 inches wide, and each will accommodate one row of saggers, but the lowest level, which is somewhat wider, is directly opposite the doors and near to flue openings from the next compartment below it. Here the wood is thrown to burn directly in front of the openings which admit hot air from the cooling compartment below. The flame passes upward to the crown or through the bungs of saggers and out the series of openings at the upper side into the next compartment. In this way, a cooling compartment preheats the air before it enters the firing zone. The first and lowest compartment is preheated by firing a small chamber just below the main kiln and connected with it.

It takes approximately three months of normal production to fill one of these big kilns and a village will be built around from one to six of them. Such work in China is carried on by families, and a potter practically lives next to his wheel, aided by his wife and children. A section of a kiln may be owned by one family and part of it may be rented to another group, while a well-to-do potter may own several sections or have part interest in separate kilns.

When a kiln is filled and ready for firing, all who share in it must contribute wood for a preliminary firing of the small chamber connected to the lowest compartment. This firing is carried on for approximately twenty-four hours before firing starts in the first compartment. Wood, 3 to 5 inches in diameter (see Fig. 4 (*C*)), is fed in through a small opening in each door for about one day until, by draw trials or by experience, the foreman judges the right amount of heat has been obtained. The firing is then started in the next compartment and so on until the end, a total of seven days.

These kilns are efficient, but they have the disadvantage that all who use one must wait until the entire space is filled with saggers. The ware nearest the fire is often overfired. No good temperature measurements are available. About fifty miles north from Tehwa is another little-known porcelain center at Mintsing. Its products and methods, as well as raw materials, are similar to those at Tehwa. One of the author's students who worked at Mintsing placed some pyrometric cones in a sagger about the center of one compartment; cone 14 was reported to have been down in a typical firing.

V. Decoration

White Tehwa porcelain is still quite common, but a large production of ware decorated with overglaze colors is now an important part of the output (see Figs. 3 (*B*) and 4 (*D*)). Plain white teapots, teacups, trays, etc., are bought by the decorators from the kilns where they are fired and are carried into Tehwa for decoration. A decorator's shop is generally provided with the common colors and will quickly make to order any of a number of standard designs. In one shop, a well-known American brand of liquid gold was used, but Japanese and British colors are common.

Before leaving Tehwa after a three-day visit, the author and others in the party ordered special tea sets, each consisting of a teapot, ten cups, and a tray. Special designs and colors were selected, and an inscription was written in Chinese upon each piece commemorating the visit. These sets were ready and delivered to a place nearly fifteen miles away two days after ordering. The price of each twelve-piece set, specially made up and delivered, was 40 cents (U. S. currency).

The overglaze colors are fired in a small, crude, updraft muffle kiln about seven feet high (see Fig. 3 (*B*)). Wood is burned in openings near the floor, and the flame passes upward around a sort of tile muffle containing the decorated pieces.

VI. A Glimpse into the Past

When asked how old Tehwa is the potters always answer vaguely that it is very old. The furnaces are not used very often and seem to be well built. Every village, however, has old furnaces out of use, waiting for repairs, and some are too old to recondition. When a kiln site has been used

for a long time, broken saggers and pottery so fill the place that a new site is chosen rather than remove the débris from the old location.

Just as the recent widespread road-building program in China has uncovered large quantities of pottery from graves, so the road cuts near Tehwa have uncovered long-buried kiln sites where no trace of them could be seen above ground. Within a mile from Tehwa, two such sites were found with broken white porcelain showing in cuts in the bank. Over one of these sites a tree with a trunk fourteen feet in circumference was growing. By digging at the roadside, parts of saggers as well as a number of broken cups were removed. These were quite different in shape from those now made there. All authorities agree that Tehwa was making white porcelain during the Ming dynasty and is therefore at least five hundred years old, but the belief is growing that it is considerably older than that.

Acknowledgments and Corrections

The expenses for the visit to Tehwa, described here, were paid by the Fukien Culture Society at Fukien Christian University in Foochow. Thanks are due to missionaries and Chinese friends who made the trip comfortable in Tehwa and on the road.

Henry Jewett Greene went along on this trip as a guest. On returning to the United States, he wrote a letter[5] to the editor of *This Bulletin* describing the Tehwa kilns. By mistake, Mr. Greene sent a photo of a kiln producing water jars which he obtained from another part of China, but labeled as coming from Tehwa.

Several other errors will become apparent by comparing the letter in *The Bulletin* with the text of this article. It is most unfortunate that this photograph should have been reproduced in a recent book[6] on Chinese glazes, as being a Tehwa kiln.

Department of Chemistry
Fukien Christian University
Foochow, China

[5] Henry Jewett Greene, "Chinese Kilns That Last for Two Firings," *Bull. Amer. Ceram. Soc.*, **15** [9] 323 (1936).
[6] A. L. Hetherington, Chinese Ceramic Glazes, opp. p. 5, Plate I. Cambridge University Press, London, 1937.

Mandrill, ceramic, by Carl Walters, a part of the Decorative Arts Exhibit at the Golden Gate International Exposition, San Francisco, February 18 to December 2. 1939.

Penguin, ceramic, by Carl Walters, a part of the Decorative Arts Exhibit at the Golden Gate International Exposition, San Francisco, February 18 to December 2, 1939.

THE PRESIDENT'S COLUMN

STUDENT RECEPTION, GENERAL MEETING, AMERICAN CERAMIC SOCIETY

One of the most important functions at the General Meeting of our Society is that of providing a reception for the ceramic students. Emerson P. Poste of Chattanooga has directed these receptions on several occasions with unusual merit. At the forthcoming Annual Meeting to be held April 16 to 22, 1939, in Chicago, Mr. Poste, with the aid of the Student Branch of the American Ceramic Society at the University of Illinois, is planning more than the usual reception for the students.

Mr. Poste addressed the Student Branch at Urbana in October, and, in coöperation with the students, developed plans for the Student Reception in Chicago.

With all the effort and work that has been done heretofore, it is probable the Student Reception has not received the attention and support from the general membership commensurate with the importance of this particular event. Unusual effort will be put forth to make the 1939 Reception an outstanding one. This will be in line with the general activities of the Forty-First Annual Meeting of the Society.

Mr. Poste and others hope to arrange the Student Reception in such a manner that it will lend itself to combining this event with the general alumni dinners. It may be said that there is perhaps no better opportunity to receive the students than by providing for their Annual Reception at a general dinner of all the alumni groups. It is therefore hoped that the membership will agree to hold the annual alumni dinners at the same time and at the same place. Placards are to be displayed at the dinner giving the name of the college or university alumni group. The students will assemble with their respective alumni members. This permits the student to become acquainted with the alumni of his college or university and with the other students.

With a little effort and coöperation, it will be possible to make this gathering one of the outstanding features of the Annual Meeting. Mr. Poste's plan will permit a "Students' Night" in which the students will have a definite part in the General Meeting.

It is needless to say that the Society will depend upon these young men to conduct the affairs of the Society a few years hence. This gives them a part in the Society during their undergraduate days.

The Student Branch of the University of Illinois, under the general supervision of Mr. Poste, will also act as hosts to the students of all the other universities and colleges and will be hosts to the alumni on "Students' Night."

This general thought outlines a most interesting evening, one in which the alumni will be permitted to meet the students from their universities and to inspire them in the work of the American Ceramic Society. Detailed plans will be announced later. Your coöperation and suggestions are solicited.

—VICTOR V. KELSEY

SEVENTY-FOUR ATTEND JOINT MEETING ART DIVISION AND MICHIGAN SECTION

The meeting as announced on page 427 of the October issue of *The Bulletin* was carried out with scheduled promptness to the delight of the seventy-four persons who attended. The Ford Motor Company, represented by F. L. Black and John A. Foster, was generous in attention and in supplying needed conveyances and guides. The Edison Institute and Museum, Greenfield Village; Cranbrook Academy, schools, science hall, and studios; University of Michigan Institute of Fine Arts; and the dinner meeting ably presided over by Karl Schwartzwalder combined to make this meeting enjoyable and instructive.

J. M. Plumer and our own John A. Foster dramatized, by exhibits, lantern slides, and lectures, the story of Chinese porcelain making.

Arthur E. Baggs, Chairman of the Art Division, was the leader in the ceramic art affairs. His motion picture in color of Indians making pottery was of the highest order in photographic and word-graphic story of this American ceramic art craft which has been continued through centuries; the most ancient ceramic craft in this hemisphere.

Cranbrook must be visited to be appreciated. Words fail to convey the beauty and the grandeur of the buildings and the landscaped hills. Nor can words written or spoken reveal the soundness and the perfection of the educational research and creative activities at Cranbrook for persons of all ages. The privilege of visiting the museums, studios, classrooms, study halls, and research laboratories at Cranbrook was greatly appreciated.

THE SEVENTH NATIONAL CERAMIC ART EXHIBITION AT THE SYRACUSE MUSEUM OF FINE ARTS, SYRACUSE, N. Y.

October 28 to November 28, 1938

This ceramic exhibit was the largest in number of pieces shown and in number of exhibitors participating. The ceramic art in clay and enamel exceeded in quality any that had heretofore been shown. The pieces exhibited were so excellent in quality that it was said that the prize pieces of previous years probably would not this year have been accepted for exhibition. The rapid and very pronounced advance in abilities to sculpture and to make pottery of clay and to use the various ceramic glazes and colors was a revelation. Mr. Winters displayed enameled panels that were unique and beautiful, showing the very excellent decorating possibilities of enameled steel panels.

Miss Anna Wetherill Olmsted, Director of the Syracuse Museum of Fine Arts, made a wonderful contribution to American ceramics when, eight years ago, she decided to direct her organizing and executive abilities to having an exhibit of American ceramic art. These exhibitions have grown in volume and in quality. She has used her rare executive ability and her enthusiasm in securing showings of these exhibits in different parts of this country and abroad. She has served American ceramics for these past eight years far beyond the confines of the Syracuse Museum of Fine Arts. We are proud to show her picture and to give a brief sketch of her experiences on the following page.

CELO KYANITE
UNIFORM QUALITY DEPENDABLE SUPPLY
FOR INFORMATION AND SAMPLES WRITE TO
CELO MINES, INCORPORATED
BURNSVILLE, NORTH CAROLINA

ANNA WETHERILL OLMSTED

Miss Olmsted is Director of the Syracuse Museum of Fine Arts, which recently moved from quarters on the top floor of the Public Library Building to a building of its own at 407 James Street. She has been art critic of the *Syracuse Post Standard* for nearly ten years and has written many articles on art for art magazines and national periodicals.

Miss Olmsted studied painting at Syracuse University and afterward traveled extensively abroad. She has exhibited at the Pennsylvania Academy of Fine Arts, the Grand Central Art Galleries in New York, and with the Associated Artists of Syracuse, of which she is a member. Miss Olmsted founded the Robineau Memorial

Anna Wetherill Olmsted, Director, Syracuse Museum of Fine Arts

Ceramic Exhibitions in Syracuse, the annual national ceramic exhibitions which have attracted both national and international attention.

With R. Guy Cowan, the noted ceramist who is Secretary of the Syracuse Museum, Miss Olmsted assembled an exhibition of Contemporary American Ceramics upon invitation from the Art and Industry Museum in Copenhagen, Denmark. This was followed by invitations from the museums of Sweden and Finland and also the Hanley Museum at Stoke-on-Trent, England. Miss Olmsted went to these Scandinavian countries to make arrangements for this Exhibition in 1936. This exhibition received high praise from the European art critics and was the first American ceramic exhibition to be invited abroad. Upon its return to America last fall, it was displayed at the Whitney Museum of American Art in New York.

On account of the attention attracted by this Exhibition in official circles, Miss Olmsted was appointed by President Roosevelt as one of the delegates on the part of the United States to the International Art Congress in Paris last summer. There were seventeen American delegates, including four women.

Biographical data about Miss Olmsted appears in the 1935–1936 edition of American Women; the Official Who's Who Among the Women of the Nation; and will appear in the 1938 Edition of Who's Who in New York State.

GOLDEN GATE MEETING WEEK AUGUST 6–12, 1939, SAN FRANCISCO, CALIF.

Previous Decision

Two years ago the Board of Trustees decided to hold a General Meeting in San Francisco in the autumn of 1939. This decision was reaffirmed this year. To set the time, place, and activities, a meeting was held on Friday, August 26, 1938.

Time

The week of August 6 was chosen because (*a*) many of the schools on the Coast open the latter part of August and (*b*) those attending from the East can return home in time for their school opening the first week in September.

Hotel

Hotel St. Francis was selected as headquarters because (*a*) it will be headquarters for the Chemical Congress, (*b*) its central location, and (*c*) its capacity and elegance.

Gift Show

The gift show exhibit will occupy three floors of the Palace Hotel that same week. Much pottery and glass will be shown.

Chemical Congress

Rene Engel plans to have a congress of several allied groups in meetings and an exhibit the week of August 6.

Mineral Exhibit

Dorsey A. Lyon is well along with plans for an extensive mineral and mining exhibit at the Exposition. The eleven western states and the Exposition have the finances and plans completed. Space will be furnished without charge or caretaker cost to ceramics. Four panels have been definitely allotted to ceramics.

Decorative Art

Mrs. Dorothy W. Liebes, Chairman of Decorative Arts for the Exposition, asked for and was assured coöperation. The participation of ceramic artists the country over will be solicited. As published on page 347, August issue of *The Bulletin*, the National Ceramic Exhibit of Syracuse is scheduled.

Ceramic Day

Walter Reimers, Director of Events and Ceremonies, has definitely pegged Monday, August 7, as Ceramic Day. He will help to schedule radio talks, meetings, and other events.

The Exposition

Construction work is nearing completion. All planned events appear to be definitely scheduled. Sale of exhibit space is progressing satisfactorily.

Meeting Schedule

Sunday, August 6: Registration and scheduled sightseeing.

Monday, August 7: Ceramic Day at Exposition: (*a*) banquet with noted speaker, (*b*) salute to American ceramics.

Tuesday through Friday Forenoons

General technical sessions at Hotel St. Francis. Afternoons and evenings will be devoted to guided tours of the Exposition, city ceramic industrial plants, and universities.

WHY CORPORATION MEMBERSHIPS

- The American Ceramic Society is America's only organization exclusively devoted to promoting ceramic arts, science, and technology.
- This Society is a nonprofit corporation expending its entire income on
  (*a*) promoting and publishing original researches,
  (*b*) abstracting world-wide ceramic literature,
  (*c*) promoting ceramic researches in federal and state surveys, bureaus, institutes, and universities.
- Audited financial statements show that 67% of the Society's income is expended on publications.
- The $12.50 dues from 1807 personal members is not adequate to conduct many activities in which this Society should be engaged and publish all of the available research reports.
- Industrial progress has always been made and will continue to be made by the industries that coöperatively make public record of researches and observations.
- Ceramic corporations have profited from the activities of the American Ceramic Society. They would profit more if each corporation invested the minimum of $25.00 annually with the Society.
- The American Ceramic Society is an effective means for the employees of ceramic corporations to continue their education.

PAID MEMBERSHIP RECORD

Date of Record	Members		Deferred	Subscriptions	Monthly Sales	Total Circulation
	Personal	Corporation				
December 20, 1936	1452	196				
December 22, 1937	1713	220	12	523	220	2688
January 22, 1938	1712	220	12	530	220	2694
February 18, 1938	1728	217	15	540	220	2720
March 18, 1938	1770	216	10	513	220	2729
April 18, 1938	1635	205	60	527	220	2647
May 19, 1938	1643	208	52	548	220	2671
June 21, 1938	1675	210	49	563	220	2717
July 19, 1938	1687	212	41	573	220	2733
August 19, 1938	1701	214	37	574	220	2746
September 19, 1938	1738	216	37	580	220	2791
October 19, 1938	1780	215	27	577	220	2819

NEWS OF MEMBERS

ROSTER CHANGES DURING OCTOBER*

Personal

COOK, RALPH L., 304 W. Michigan Ave., Urbana, Ill. (North East, Pa.)

EBRIGHT, MORT W., 1916 E. 84th St., Cleveland, Ohio. (Columbus, Ohio)

FERGUSON, ROBERT F., 77 Highland Ave., Washington, Pa. (Zanesville, Ohio)

LYNN, BERT M., 235 North Wilton Place, Los Angeles, Calif. (Mount Vernon, N. Y.)

MAUPIN, ADDISON, General Refractories Co., 1600 Real Estate Trust Bldg., Philadelphia, Pa. (West Decatur, Pa.)

SMITH, DONALD I., Box 692, University, Ala. (Washington, D. C.)

SOCIETY of GLASS TECHNOLOGY, "Elmfield," Northumberland Rd., Sheffield, 10, England. (Darnall Rd., Sheffield, England)

TURNER, WALTER M., Corning Glass Works, Wellsboro, Pa. (Corning, N. Y.)

TURNER, W. E. S., "Elmfield," Northumberland Rd., Sheffield, 10, England. (Darnall Rd., Sheffield, England)

WEBSTER, PAUL A., Box 77, Bloomfield, Conn. (Hartford, Conn.)

NEW MEMBERS

Personal

DELGADO, CYRIL B., *Glass Industry*, 11 W. 42nd St., New York, N. Y.; advertising manager.

†FAIRCHILD, CHARLES O., Park & Nostrand Aves., Brooklyn, N. Y.; research director, C. J. Tagliabue Mfg. Co.

HODSON, GEORGE N., 58 Park Rd., Loughborough, England; managing director, Hathernware, Ltd.

JOEL, SALVATORE, 49 Thorne St., Jersey City, N. J.; ceramist, Church Statuary Co.

*Address in parentheses is the former address.

†Indicates former member of the Society rejoining for 1938.

†LAWSON, CARL H., 26 Chester Brook Rd., Waltham, Mass.; superintendent, Waltham Grinding Wheel Co.

RUSSELL, ROBERT G., 3435 Elaine Place, Chicago, Ill.; ceramic engineer, Torstenson Glass Co.

SKINNER, Ransom P., 245 Union St., Hamburg, N. Y.; superintendent, The Exolon Co.

SOMERVILLE, THOMAS, III, 101 Chamberlin Ave., Chevy Chase, Md.; president, Washington Brick Co.

STECK, C. O., 1 Twenty-Eighth St., Pittsburgh, Pa.; Kress Box Co.

†STOIN, S. M., 1015 Gaston Ave., Cambridge, Ohio; ceramic engineer, Universal Potteries.

†TRABERT, LOREN A., 1234 W. Harding Way, Stockton, Calif.; superintendent, Joaquin Potteries, Inc.

WARD, WILLIAM P., 168 Water St., Perth Amboy, N. J.; research assistant, International Smelting & Refining Co.

†WHITTEMORE, O. J., Vincent Clay Products Co., 615–619 State Bank Bldg., Fort Dodge, Iowa; sales manager.

Student

University of Illinois: BOEKER, JUSTIN R., CICHOWSKI, VAL J., EYERLY, GEORGE B., WEBBER, JOHN J., AND WOLFENSBERGER, ROBERT E.

North Carolina State College: GATTIS, CHARLES M., JR., AND MILLER, HOWARD L.

Pennsylvania State College: CRAMER, WILLIAM R., AND LAMBIE, JAMES M., JR.

MEMBERSHIP WORKERS' RECORD

Personal			
Grant S. Diamond	5	J. T. Ogden	1
Robert F. Ferguson	1	Earl Solomon	1
T. W. Garve	2	Oscar F. Zeiller	1
A. F. Greaves-Walker	2		
Student			
A. I. Andrews	5	E. C. Henry	2
A. F. Greaves-Walker	1	R. L. Stone	1
		Grand Total	**22**

GIFTS TO THE AMERICAN CERAMIC SOCIETY

The late W. D. Richardson, Charter Member of the Society, generously bequeathed his technical library and bookcases to the Society. There are three sectional bookcases, two of four sections each and the third of six sections.

One section is being used to display a collection of minerals which have been sent in by various members of the Society and which is growing rapidly.

From Mr. Richardson's library there are one hundred and twenty-five bound books. These include copies of geological survey reports, several from Ohio, and others from Georgia, Wisconsin, New York, and Iowa. The bound volumes of technical magazines include (1) *Brick* for 1903 to 1907, inclusive; (2) *The Clay-Worker* from 1891 to 1907, inclusive; (3) *Tonindustrie-Zeitung* from 1904 to 1907, inclusive. Other valuable books are included in this gift.

Mr. Richardson was a frequent visitor to this office and was always interested in the pictures, the books, and the exhibits which are ever increasing in value and interest. The members of the Society will be grateful to know that Mr. Richardson's personal technical library will have a permanent home, where it will benefit many people, even those who never knew him.

Gift from Walter Fickes

Walter M. Fickes, Badin, N. C., recently visited the offices of the Society and presented fifteen bound copies of the *Transactions of the American Ceramic Society*. This gift was particularly important because several of the copies included are out of print and are being sought for by active members of the Society. Mr. Fickes was a member of the Society for many years. He was the first graduate in ceramic engineering at Ohio State University in 1900.

Atholl McBean and W. P. Stephens Present Pottery

From Gladding, McBean & Company, a jardinière, copper red outside with copper green inside, has been presented to the Society by Atholl McBean.

From the Pisgah Forest Pottery, Mr. Stephens has sent a blue crackle glaze vase and another one of copper red.

The Society's museum and library are growing in extent and value. These are destined to be two assets highly prized and of educational importance. Contributions by the members are sought.

NECROLOGY

GAIL ROYDEN TRUMAN

Members of the Society will be saddened with the information of the death of Gail R. Truman on June 26, 1938

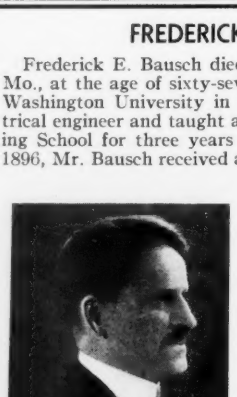
Mr. Truman was born in Genoa, Ohio, May 12, 1888, the son of Dr. Horace F. Truman and Anna C. Truman. He attended the Toledo public schools and was graduated from Central High School in January, 1903. From 1909 to 1911, Mr. Truman attended Ohio State University, completing the Short Course in Ceramics. From 1911 to 1921, he was ceramist with the St. Louis Terra Cotta Company, St. Louis, Mo. During this period he was instrumental in organizing the St. Louis Section of the American Ceramic Society; he became a member of the Society in 1912.

Gail R. Truman

From January 1921 to 1923, Mr. Truman was ceramist for the Tropico Potteries of Los Angeles, which later became the Gladding, McBean & Company. During the years 1925 to 1935, he was chief ceramist for the Clay Products Company, Brazil, Ind., where he pioneered in the manufacture of glazed hollow block. From October, 1935, until the time of his death, Mr. Truman was chief ceramist for the Hanley Company, Summerville, Pa. His death was due to angina pectoris. He is survived by his wife, Leslie Campbell Truman, a son, Clark, and his mother.

FREDERICK E. BAUSCH

Frederick E. Bausch died April 18, 1938, in St. Louis Mo., at the age of sixty-seven. He was graduated from Washington University in 1892 with the degree of electrical engineer and taught at the St. Louis Manual Training School for three years following his graduation. In 1896, Mr. Bausch received a Master's degree from Cornell University. He then became an electrical engineer with the Bell Telephone Company of Missouri. Mr. Bausch also held the following positions: 1898–1900, mechanical engineer, Missouri Edison Electrical Company; 1900–1901, chief engineer, Pittsburgh Plate Glass Co., Crystal City, Mo.; 1901–1923, manager, St. Louis territory, Hooven, Owens, Rentschler Company of Hamilton, Ohio; 1903–1923, also proprietor of Frederick E. Bausch Fire Clay Mines in St. Louis County and crucible clay mines, Kaolin, Ill.



F. E. Bausch

Mr. Bausch became a member of the American Ceramic Society in 1919. For many years he was active in the work of the St. Louis Section and served as an officer.

Mr. Bausch is survived by one brother, Adolf Bausch, of St. Louis.

CERAMIC SCHOOL NOTES

OHIO STATE UNIVERSITY STUDENT BRANCH

An organization meeting of the Ohio State University Student Branch of the American Ceramic Society was held October 12. G. W. Brainerd, who has spent several years in the study of early American pottery, gave an address on "The Use of Ancient Ceramic Relics in Determining Early Civilizations."

VIRGINIA POLYTECHNIC INSTITUTE

The Virginia Polytechnic Institute Student Branch of the American Ceramic Society has organized for the present school year with a membership of twenty-six. Officers for the year are as follows: *President*, R. G. Charles; *Vice-President*, J. D. Braddock; and *Secretary-Treasurer*, W. H. Hitt. J. W. Whittemore is councillor.

Meetings are held twice a month with two brief informal talks scheduled for each meeting. Plans are being made to secure several films on subjects of general ceramic interest to fill in the program for the year.

—Wade H. Hitt, *Secretary*

GEORGIA SCHOOL OF TECHNOLOGY FIFTIETH ANNIVERSARY

The fiftieth anniversary of the founding of the Georgia School of Technology was celebrated on October 7, 8, and 9, 1938, by exercises, exhibits, and festivities of interest to the alumni and general public. The large industrial exhibit included many specimens of machinery, textiles, and commercial products which have resulted from the advance of engineering during the past fifty years. These exhibits were made possible through the coöperation of many commercial houses. Each department of engineering showed in its departmental laboratories specimens of the work of that laboratory and exhibits of raw materials, processes, and products. The Ceramic Engineering Department had exhibits of refractories, Georgia minerals, pottery, and various uses of Georgia kaolin, in addition to a demonstration of the casting of pottery. Each visitor was given a souvenir ash tray, taken directly from the glaze kiln.

Formal exercises commemorating the anniversary were held October 8, when the academic procession, headed by distinguished guests and delegates, marched to the new auditorium-gymnasium, which was being used for the first time. The assemblage was addressed by Governor E. D. Rivers, of Georgia, and by F. P. Graves, President of the Phi Beta Kappa Society. Athletic contests, such as a golf match between Bobby Jones, Charlie Yates, Watts Gunn, and Dick Garlington, all famous golfers and alumni of Tech, and the tennis match between Bryan Grant and Russell Bobbett, were staged for the entertainment of guests. The football game between Georgia Tech and Notre Dame culminated this phase of the program. Dances were held Friday and Saturday afternoon and night, and the numerous social occasions included a reception for the distinguished guests by Governor and Mrs. E. D. Rivers, a dinner for all alumni given by Dr. M. L. Brittain, President of Georgia Tech, and a dinner for the visiting delegates given by Dr. and Mrs. Brittain.

Student Branch Meeting

The Georgia Tech Student Branch of the American Ceramic Society held its first meeting on September 28, 1938. The following officers for 1938–1939 were elected: *President*, Emory Clark; *Vice-President*, Harold Dye; *Secretary*, J. L. Nunes; and *Treasurer*, H. B. Grace. Fol-

lowing the election, W. H. Vaughan, head of the State Engineering Experiment Station, gave a short talk.

On October 12, the sophomore ceramic class was entertained at a weiner roast.

JOSEPH PALIN THORLEY AT UNIVERSITY OF PITTSBURGH

Joseph Palin Thorley is conducting a cultural and avocational course in ceramic art at the University of Pittsburgh, Pittsburgh, Pa. This course is not intended to provide training for professional ceramists, but it will give the student an opportunity to work with his hands in the studio and learn the fundamentals of line, form, and proportion. Lectures and individual work will provide instruction in the history, technology, and design of ceramics as one of the fine arts.

The Department of Fine Arts of the University of Pittsburgh occupies the entire thirtieth floor of the Cathedral of Learning with equipment of professional standard.

Educated in England

Professor Thorley received his education in England. He was graduated from the Stoke-on-Trent Art Schools, where he later taught. He also occupied the position of head of the pottery design and research classes. He later studied at the Victoria and Albert Museum in London and at the Pottery School at the Staffordshire College of Science, where he took a post honors course; and in Paris, Dresden, Berlin, and Copenhagen.

For twelve years, Professor Thorley was with Josiah Wedgwood & Sons, in later years as assistant to the Art Director, Mr. Goodwin. He also held the positions of Art and Technical Director to the New Chelsea Porcelain Company and Allertons, Ltd., and Consultant Art Director to the Bristol Potteries in England.

In 1928, Professor Thorley came to this country. He held successively the positions of Art Director to the Leigh Potters, the American Chinaware Corp., and Taylor, Smith, & Taylor.

Recently Professor Thorley established the Thorley Studios of Industrial Design at Richmond, Va., where he has been designing, not only for ceramics, but for other industries. Professor Thorley became a member of the English Ceramic Society in 1918 and the American Ceramic Society in 1933.

Joseph Palin Thorley

LOCAL SECTIONS

NORTHERN CALIFORNIA SECTION

On Tuesday, October 11, 1938, the Northern California Section of the American Ceramic Society met at the Stockton Fire Brick Co. plant near Pittsburg, Calif. After a "feed" given by the management of the Company, the members of the Section visited the steel mill of the Columbia Steel Co. in Pittsburg.

—G. A. PAGE, *Secretary*

PITTSBURGH SECTION

The Pittsburgh Section of the American Ceramic Society met Tuesday, October 11, 1938, in the auditorium of Mellon Institute, Pittsburgh, Pa. S. R. Scholes, Head of the Department of Glass Technology, New York State College of Ceramics, Alfred, N. Y., spoke on the subject "The Composition and Properties of Laboratory Glasses." Ninety members were present at this meeting.

Erwin Sohn, Director of Research of the Standard Sanitary Manufacturing Co., Louisville, Ky., was the speaker at the meeting held November 8, 1938.

—C. L. THOMPSON, *Secretary*

SOUTHERN CALIFORNIA SECTION

The Southern California Section held a dinner meeting at the Brack Shop in Los Angeles, September 21, 1938.

Willard J. Sutton, of Fukien University, Foochow, China, repeated his lecture which was given at the New Orleans Meeting. He added remarks concerning the present situation in China to his formal lecture. China's future destines her to be one of the greatest countries within a few decades. Dr. Sutton's talk was appreciated by the members and aroused deep interest in Chinese ceramic artwork.

—F. A. MCCANN, *Secretary*

Membership in American Ceramic Society
FOR CONTINUING EDUCATION IN CERAMICS
Forward-going aggressive persons succeed only by continually studying, not narrowly, but broadly, the current problems in all ceramic fields.

MEETINGS PLANNED

FORTY-FIRST ANNUAL MEETING, HOTEL STEVENS CHICAGO, ILL., APRIL 16–22, 1939

GENERAL MEETING, HOTEL ST. FRANCIS SAN FRANCISCO, CALIF., WEEK OF AUGUST 6, 1939

ART DIVISION AND PITTSBURGH SECTION, UNIVERSITY OF PITTSBURGH AND MELLON INSTITUTE, JANUARY 10, 1939

Bumper attendance and fine programs have characterized the Autumn Meetings of the Art, Enamel, Glass, Refractories, White Wares, and Materials and Equipment Divisions. These informal gatherings promote personal friendships that make easier the solving of industrial problems. The Enamel Forum under the auspices of the Porcelain Enamel Institute was successful in all respects. The plan of the Art Division to schedule several midyear meetings such as were held at Blue Ridge, N. C., in August; in Dearborn, Mich., October 23–25; in Syracuse, N. Y., October 27 and 28; and as arranged for in Pittsburgh, January 10, marks the beginning of a planned circuit of meetings in different cities and jointly with the several Local Sections of the Society.

Meetings of the several Local Sections have been well attended, and instructive programs have been given. The Student Branches are active with meetings, shows, and social affairs that demonstrate the worth of these organizations.

The American Ceramic Society is alert, progressive, and stimulating.

WATCH YOURSELF GROW BY GETTING MORE NEW MEMBERS

ART DIVISION MEETING AT SYRACUSE

Members of the Art Division met in a two-day session at Syracuse, N. Y., October 27–28. This meeting followed immediately upon the successful Art Division meeting held October 24–25 at Dearborn, Mich. Another meeting of the Art Division will be held in Pittsburgh, Pa., on January 10, 1939.

Thursday, October 27

5:00 P.M.: Cocktails at the Onondaga Hotel, Syracuse, N. Y.
6:30 P.M.: Dinner at Onondaga Hotel.
8:00 P.M.: Reception and opening of the Seventh National Ceramic Art Exhibition at the Syracuse Museum of Fine Arts.

Friday, October 28

9:30 A.M.: Private view of the National Ceramic Art Exhibition for Art Division members.
10:30 A.M.: Meeting of Art Division at Syracuse Museum of Fine Arts.
"The Exhibition" by R. GUY COWAN.
Discussion on "How Shall We Broaden the Influence of the Exhibition?"
11:30 A.M.: Questions and Answers: Led by CHARLES HARDER; assisted by ROSS C. PURDY and R. GUY COWAN.
2:00 P.M.: Trips arranged to the Onondaga Pottery and Syracuse University.

About 275 ceramic artists submitted work to the Exhibition, and the judges stated that there were about twice as many *good* pieces as were submitted last year with a total receipt of nearly three times as many as in 1937.

—R. GUY COWAN, *Chairman*

A Heap of Living Makes the Home
A Heap of Study and Unremitting Work Brings Success
A Faint Heart Never Achieves
He Succeeds Who Determines So to Do

CERAMIC HISTORY

HERMANN AUGUST SEGER

Hermann August Seger was born in Gnesen, Germany, on December 26, 1839, and died on October 30, 1893. When he was twenty years old, he matriculated as a student at the Royal Trade Academy (later Technische Hochschule) in Berlin, where he studied chemistry and worked in the organic laboratory as assistant to Dr. Schöne, who was then engaged in the perfection of his well-known elutriating apparatus used in the clay industry.

Seger soon was surrounded with a group of men who made names for themselves: Dr. Aron with whom Seger later joined in his *Tonindustrie-Zeitung* enterprise; Dr. Hertzog, manager of a cement plant and later of a face brick plant and then manager of the Royal Porcelain Works of Berlin; A. Bernoully, a cement manufacturer; E. Peters, Secretary of the Society of German Engineers; Dr. Zwick, editor of the yearbook on the progress in the building industries; and Dr. C. Heintzel in Lüneburg and Dr. W. Michaelis in Berlin.

The customary "Wanderjahre" had their stimulating influence upon him, and he was active in various capacities in various industrial plants. So we find him, for example, in Neuwied-on-the-Rhine, where for several years he was manager of the alum and vitriol works; in Rostock, the university seat of Mecklenburg, where he obtained his Ph.D. degree in 1868; and, finally, in a chemical factory in Sweden. After his return to Germany, he decided to devote his time and energy to the development of the clay industry soon after Friedrich Hoffman had invented the continuous kiln and Schlickeysen, the auger machine.

After several years of activity in Germany he again went to other countries, to Belgium, England, and Hungary, where he found much that was superior to German practice.

After his return, he became intimately associated with Türrschmidt, the originator and editor of the publication, *Notizblatt*, and with Hoffman. Seger's first writings were published in 1870 in the *Notizblatt;* among these were "The Disintegrating Process of Crystalline Rocks and Its Influence upon the Structure of Clays" and "The Crystal Formations and Their Importance to the Clay Industries."

Seger joined Türrschmidt's laboratory and editorial office which had published since 1869 the *German Pottery and Brick Journal*, and since 1865 the *Transactions of the German Society for the Manufacture of Brick, Clayware, Lime, and Cement;* the latter became the *Notizblatt*, which again was the forerunner to the *Tonindustrie-Zeitung*. After Türrschmidt's death in 1871, it was Hoffman's suggestion that Seger take over the editorial management of the *Notizblatt*, which he did in association with Dr. Aron, thus laying the foundation for the later nationally and internationally well-known "Chemische Laboratorium für Tonindustrie und Tonindustrie-Zeitung, Prof. Dr. H. Seger and E. Cramer, Berlin."

It is safe to say that without Seger's untiring efforts Hoffman's continuous kiln would have gone the way to oblivion, as most inventions go. Unfortunately, the invention came out at a time when buff face brick was in style. The kiln was blamed for the failures in firing this kind of brick, and it was Seger who introduced the watersmoking system by using the hot air from cooling sections found on most continuous kilns of this type up to this day. For the manufacture of such buff brick from limey clays, Seger introduced the reducing fire through backward-directed draft. He pointed out that with predominating oxidizing fire the sulfuric acid of the combustion gases converts the calcium carbonate of the clay to gypsum, preventing its combination with silica, whereas, with alternating forceful reduction, the sulfuric acid is volatilized as sulfurous acid so that the silica in the clay with its iron content forms a buff-colored calcium carbonate with the lime. Seger's success soon became known and there was a time when he would go from plant to plant for Hoffman, to work and fight for the existence and development of the Hoffman continuous kiln.

With the beginning of the year 1877, Seger, in association with Dr. Aron, was the founder of the *Tonindustrie-Zeitung* (the first number of this paper carries the date December 2, 1876), to which soon was added a testing laboratory. The paper was a success from the beginning, not alone because of Seger's name but because Seger displayed character and vision enough to secure the services of the best-known men in the industry of Germany, as well as of other countries, as regular contributors to his paper. When Seger was called to serve as technical adviser to the State of Prussia, he accepted, but he maintained his activity and influence with his paper and laboratory.

The *Tonindustrie-Zeitung* and laboratory grew from year to year, moved to larger quarters, added new branches (a complete library of all known books on ceramics, etc., a factory for the manufacture of testing machinery and apparatus, etc.) and new names of renown to the staff, and became a unique institution of international reputation.

Later the *Keramische Rundschau* was added to separate fine ceramics from structural clayware.

In 1877, Seger wrote the fundamental paper, "The Place of the Continuous Kiln in the Clay Industry," clarifying the situation in regard to colors from iron and lime with oxidizing and reducing fires. During 1877 to 1879, he published a practical method for the analysis of industrial gases, reported on the effect of combustion gases in ceramic kilns, and on the distribution and character of the fire in ceramic kilns. He also published "The Influence of the Various Ingredients of Clay upon Fusibility," "Investigations of Bodies for Fine White Earthenware," "The Relation between Composition and Behavior of Sennewitz Kaolin in the Firing," "The Composition of Some Foreign Bodies for Hard Porcelain," etc.

In 1878, Seger was appointed director for the newly established testing laboratory added to the Royal Porcelain Works of Berlin, upon Möller's recommendation. "Seger belongs to the very limited group of chemists who have made a name for themselves by fundamental and valuable contributions to the field of ceramics, which up to their time had been almost wholly neglected. He furthermore

has the ability in an unusual large measure to interpret scientific research and find for it the practical application, and therefore is eminently qualified for the position." But Seger stuck to the *Tonindustrie-Zeitung* in spite of the additional burden and continued his activity as lecturer and teacher at the Royal Trade Academy, Berlin. Impaired health, however, forced him to relinquish some of his many activities during the following years, though his connection with the laboratory of the Porcelain Works lasted until October, 1890.

Of course, any life sketch of Seger must mention his Seger Kegel or Seger cone. He developed the first series during his activity with the laboratory and reported about it during 1886 in the *Tonindustrie-Zeitung* under the title, "Standard Cones for the Measurement of Temperatures in the Kilns of the Ceramic Industries." The first continuation of this work was published in 1888 under the title, "Standard Cones."

Even though the first art objects made from "Seger porcelain" were produced and marketed during 1880, Seger must have worked on the problem quite some time prior to this, and it seems that impetus was given him in some measure through an explicit letter he received from a friend in Japan, describing in detail the composition and manufacture of some Japanese porcelain.

Seger was one of the first who fully understood the technique of copper-oxide glazes and could carry out the manufacture of "china red." He did much other fundamental work (with the ceramic artist Timm) on glazes and decorations of a great variety, not alone in their technical performance but also in their scientific formulation, not to mention the investigation from oriental sources of the transparent relief enamel, etc.

Although Seger lived only fifty-four years, he left about 170 treatises. He was married in 1875 to Mrs. Emma Schur, *née* Schmidt. Seger was of pronounced character with a great devotion to duty, modesty, willingness to sacrifice and to help and to assist without limitation.

The reporter has sketchily presented what he found, but he feels ill at heart to render an account so brief for a man who has made history.

NOTES AND NEWS

ENGLISH ENAMELERS' VISIT TO AMERICAN PLANTS

The Porcelain Enamel Institute assisted the Institute of Vitreous Enamellers of London, England, in arranging plant visitations in various cities in the United States. The entire tour in the States was covered in ten days, visiting eight cities and thirteen plants, including two days at the Porcelain Enamel Institute Third Annual Forum held at Urbana, Ill. A United Airlines Skylounge plane was chartered for their entire visit in the States.

The English enamelers arrived in New York City, Saturday, October 8.

Members of the Institute of Vitreous Enamellers of England on their visit to the United States and attending the Third Annual Porcelain Enamel Institute Forum, University of Illinois, Urbana, Illinois, October 12–14, 1938.

Front row, left to right: W. Astles, Union Oxide & Chemical Co.; C. J. Baines, C. J. Baines & Co.; J. Nicholls, Hurst Hill Enamel Co.; A. H. Gray, Jas. Gray & Sons, Ltd.; and C. P. Stone, Ferramic Industries, Ltd.

Back row: W. H. Whittle, W. H. Whittle, Ltd.; A. J. Somers, Borax Consolidated, Ltd.; Bernard B. Kent, Sterling Mfg. Co.; F. Gieseke, Kockums Emaljerverk, Ronneby, Sweden; and A. Thomason, F.I.C. Stewart & Co., Ltd.

PORCELAIN ENAMEL INSTITUTE MEETINGS

The Eighth Annual Meeting and Sales Conference of the Porcelain Enamel Institute will be held in Cleveland, at the Hotel Statler, November 16 and 17. This meeting had previously been announced for October 25 and 26.

The meeting was deferred until November because of the rapidly improving business in the porcelain enameling industry. If improvements noted at this time continue, the middle of November should see many branches of the industry operating at a favorable rate.

Porcelain Enamel Institute Handbook

The Porcelain Enamel Institute announces the publication of a revised edition of the handbook, Test for Acid Resistance of Porcelain Enamels. It was prepared under the direction of the Institute's Committee on Standardization of Tests, of which W. N. Harrison, National Bureau of Standards, is chairman. This test has been officially adopted as the "standard test," replacing the "tentative test" issued by the Institute some time ago. Complete instructions under each classification for simple methods of determining the acid resistance of porcelain enamels are included in the manual.

Copies may be obtained through the Institute headquarters, 612 N. Michigan Ave., Chicago, Ill.